FRAMEWORK OF SIX SIGMA IMPLEMENTATION ANALYSIS ON SMEs IN MALAYSIA FOR INFORMATION TECHNOLOGY SERVICES, PRODUCTS AND PROCESSES

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Abstract

For the past two decades, the majority of Malaysia's IT companies have been widely adopting a Quality Assurance (QA) approach as a basis for self-improvement and internal-assessment in IT project management. Quality Control (QC) is a comprehensive top-down observation approach used to fulfill requirements for quality outputs which focuses on the aspect of process outputs evaluation. However in the Malaysian context, QC and combination of QA and QC as a means of quality improvement approaches have not received significant attention. This research study aims to explore the possibility of integrating QC and QA+QC approaches through Six Sigma quality management standard to provide tangible and measureable business results by continuous process improvement to boost customer satisfactions.

The research project adopted an exploratory case study approach on three Malaysian IT companies in the business area of IT Process, IT Service and IT Product. Semi-structured interviews, online surveys, self-administered questionnaires, job observations, document analysis and on-the-job-training are amongst the methodologies employed in these case studies. These collected data and viewpoints along with findings from an extensive literature review were used to benchmark quality improvement initiatives, best practices and to develop a Six Sigma framework for the context of the SMEs in the Malaysian IT industry.

This research project contributed to both the theory and practice of implementing and integrating Six Sigma in IT products, services and processes. The newly developed framework has been proven capable of providing a general and fundamental start-up decision by demonstrating how a company with and without formal QIM can be integrated and implemented with Six Sigma practices to close the variation gap between QA and QC. This framework also takes into consideration those companies with an existing QIM for a new face-lift migration without having to drop their existing QIM. This can be achieved by integrating a new QIM which addresses most weaknesses of the current QIM while retaining most of the current business routine strengths. This framework explored how Six Sigma can be expanded and extended to include secondary external factors that are critical to successful QIM implementation. A vital segment emphasizes Six Sigma as a QA+QC approach in IT processes; and the ability to properly manage IT processes will result in overall performance improvement to IT Products and IT Services. The developed Six Sigma implementation framework can serve as a baseline for SMEs to better manage, control and track business performance and product quality; and at the same time creates clearer insights and un-biased views of Six Sigma implementation onto the IT industries to drive towards operational excellence.

List of Publications

Whee Yen Wong, Chan Wai Lee, and Kim Yeow Tshai, "A Roadmap to Quality Improvement Methodology Selection," in *3rd IEEE International Conference of Emergency Management and Management Science, ICEMMS* Beijing, pp. 310-315, 2012.

Whee Yen Wong, Chan Wai Lee, and Kim Yeow Tshai, "Six Sigma in IT Processes, IT Services and IT Products - A Fact or a Fad?" in *12th International IEEE Computer and Information Technology, CIT* Chengdu, pp. 524-531, 2012.

W. Y. Wong, K. Y. Tshai, and C. W. Lee, " The Evolution of Quality Improvement Methodology in Malaysia's IT Industry: The Past, Current and Future" *World Academy of Science, Engineering and Technology, International Science Index 72, International Journal of Mechanical, Industrial Science and Engineering*, Volume 6, Issue 12, pp 15 – 24, 2012.

Whee Yen Wong, Chan Wai Lee, and Kim Yeow Tshai, "A Review of Quality Relationship between IT Processes, IT Products and IT Services" in *33^{rd} International Conference on Information Systems, ICIS* Penang, pp. 445-451, 2012.

Whee Yen Wong, Kim Yeow Tshai, and Chan Wai Lee, " The Evolution of Quality Improvement Methodology in Malaysia's IT Industry: The Past, Current and Future" in *33^{rd} International Conference on Information Systems, ICIS* Penang, pp. 167-176, 2012.

F. A. Rishafy, C. W. Lee, and W. Y. Wong, "A Review of Resistance Factors to Quality Management in the IT Sector in Malaysia", *Global Perspective on Engineering Management (GPEM),* Volume 2, Issue 3, pp 121-133, 2012.

Whee Yen Wong, Chan Wai Lee, and Kim Yeow Tshai, "The Importance of a Software Development Methodology in IT Project Management: An Innovative Six Sigma Approach " in *3^{rd} IEEE Symposium on Business, Engineering and Industrial Application, ISBEIA Kuching,* pp 130-135, 2013.

Whee Yen Wong, Chan Wai Lee And Kim Yeow Tshai , "Six Sigma Implementation in IT Software Product Industry – A Case Study Of SME In Malaysia: Six Sigma Methodology In IT Project Management", *International Journal of Computer Engineering & Technology (IJCET),* Volume 4, Issue 4, pp 475-484, 2013.

Whee Yen Wong, Kim Yeow Tshai, Chan Wai Lee, "A Review of Quality Improvement Initiatives in the Malaysian IT Industry: A Quality Improvement Handbook for SMEs" in *International Conference Image Processing, Computers and Industrial Engineering, ICICIE Kuala Lumpur, Malaysia,* pp 30-38, 2014.

Whee Yen Wong, Chan Wai Lee, and Kim Yeow Tshai, "Six Sigma Implementation in IT Service Industry – A Case Study of Helpdesk Centre in Malaysia" in *IEEE Colloquium on Humanities, Science and Engineering, CHUSER Penang, Malaysia,* pp 447-452, 2014.

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List of Abbreviations

Abbreviation	Description
AP	Action Plan
AV	Audio-Visual
B2B	Business-To-Business
B2C	Business-To-Customer
BA	Business Analyst
BB	Black Belt
BPR	Business Process Reengineering
CFF	Critical Failure Factor
CMM/CMM-I	Capability Maturity Model / Capability Maturity Model Integration
CMQF	Conceptual Model Quality Framework
COBIT	Control Objectives for Information Technology
COPQ	Cost of Poor Quality
CRM	Customer Relationship Management
CSF	Critical Success Factors
CTO	Chief Technology Officer
CTQs	Critical To Quality
DB	Database
DBMS	Database Management System
DFD	Data Flow Diagram
DFSS	Design For Six Sigma
DMADV	Define, Measure, Analyze, Design, Verify
DMAIC	Define, Measure, Analyze, Improve, Control
DoE	Design of Experiment
DPMO	Defects per million opportunities
EMS	Educational Management Information System
ETA	Estimate Time of Arrival
EVA	Earned Value Analysis
FLM	Fleet Management System
FMEA	Failure Mode Effect Analysis
FTE	Full Time Employee
GB	Green Belt
GDP	Gross Domestic Product
GPRS	General Packet Radio Services
GPS	Global Positioning System
GQM	Goal-Question-Metric
HCM	Human Capital Management
HMS	Helpdesk Management System
HR	Human Resource
HRMS	Human Resource Management System
ICT	Information, Communication And Technology
IMAC	Installation, Movement, Additional and Change of hardware and software
IS	Information Systems
ISO	International Standardization of Organization
IT	Information Technology
ITIL	Information Technology Infrastructure Library
ITSM	IT Service Management
KPI	Key Performance Indicator
KPM^3	Kerzner Project Management Maturity Model
MBB	Master Black Belt
MDeC	Malaysia Development Corporation
MOSTE	Ministry of Science, Technology and Environment
MOSTI	Ministry of Science, Technology and Innovation
MSC	Multimedia Super Corridor
MVS	Multi-Vendor Services
NBD	Next Business Day

List of Abbreviations

Abbreviation	Description
NITA	National Information Technology Agenda
NITC	National Information Technology Council
PA	Performance Appraisal
PDCA	Plan-Do-Check-Action
PL	Project Leader
PLC	Project Life Cycle
PM	Project Manager
PMM	Project Management Maturity
PMMM	Project Management Maturity Model
PSP	Personal Software Process
QA	Quality Assurance
QC	Quality Control
QI	Quality Improvement
QIM	Quality Improvement Methodology
QM	Quality Management
QMM	Quality Measurement Metric
RO	Research Objectives
RPN	Risk Priority Number
RQ	Research Questions
SDLC	System Development Life Cycle
SDM	System Development Methodology
SDM	System Development Methodology
SIPOC	Supplier-Input-Process-Output-Customers
SLA	Service Level Agreement
SLO	Service Level Objective
SME	Small Medium Enterprises
PCA	Process capability Analysis
SPC	Statistical Process Control
SPI	Software Process Improvement
SPICE	Software Process Improvement And Capability Determination
SQA	Software Quality Assurance
SQL	Sigma Quality Level
SQS	Software Quality System -1
SRS	System Requirement Specification
SSR	Six Sigma Roadmap
TPM	Total Productive Maintenance
TPS	Toyota Production System
TQC	Total Quality Control
TQM	Total Quality Management
PRINCE	PRojects in Controlled Environments
OPM3	Organizational Project Management Maturity Model
UAT	User Acceptance Test
UNMC	University of Nottingham Malaysia Campus
UNPAN	United Nations Public Administration Network
VLE	Virtual Learning Environments
VMS	Vehicle Management System
VOC	Voice Of Customer
WB	White Belt
WBS	Work Breakdown Structure
WiFi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
YB	Yellow Belt
QFD	Quality Function Deployment
ROI	Return On Investment
SSPMT	Six Sigma Project Management Tool
SPM	Software Project Management
UI	User Interface
SCAAT	School of Computer and Advanced Technologies
CAR	Casual Analysis and Resolution

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Chapter-1 Research Introduction

1.1 Overview of Information Technology (IT) Industry in Malaysia

Malaysia is preparing to be part of the "Information Age" in the new millennium by transforming itself towards a knowledge-based economy [1]. By recognizing that information technology (IT) and multimedia will be the future enabling tools to increase the efficiency, productivity and competitiveness of the economy, various improvement initiatives were taken to promote the use and development of IT in Malaysia. The National Information Technology Agenda (NITA) was formulated in 1996 to provide the framework for a coordinated and integrated approach in developing the three strategic elements comprising human resource, infrastructure and IT-based applications [1]. In order to provide the catalyst for the expansion of IT and multimedia industries in Malaysia, the Multimedia Super Corridor (MSC) was launched [1].

MSC Malaysia aims to revolutionize how the world does business [2]. MSC Malaysia located at the hub of one of Asia's fastest growing markets, is a regional launch site for companies developing or using leading multimedia technology, allowing these innovators to harness Malaysia's unique competitive advantages that arise from its multicultural links, committed leadership, and proven track record in developing products and services for regional and global markets. Malaysia's Multimedia Development Corporation (MDeC) revealed that MSC Malaysia accomplished tremendous achievements in the first phase of its development and its next set of 2010-2015 targets are to create 245,000 high value jobs, generate RM69 billion in revenue, RM28 million of exports and to create a total of 10,250 ICT Small Medium Enterprises (SMEs) and MSC Malaysia Status Companies [3, 4].

According to the United Nations Public Administration Network (UNPAN) [5], Malaysia aims to strengthen foundations for building a knowledge-based society and economy in order to integrate into the global electronic economy. In this regard, IT infrastructure will be expanded and upgraded and a number of national IT-related programs and projects will be implemented to accelerate the wider use of IT in the various sectors of the economy. This will enable Malaysia to sustain its competitiveness as well as attract new investments and create economic opportunities in IT-related industries and services.

In the context of rapid global developments in science and technology, IT has become an increasingly critical enabling tool which has led to changes in the comparative advantage and competitiveness of economies worldwide. IT has brought new changes to the management of science and technology. As a result, it became imperative that various sectors of the Malaysian economy undertake initiatives to gradually integrate new IT-based systems into existing work processes.

UNPAN revealed that global IT investments expanded at a rate of 8.4% per annum during the 1990s, increasing from RM3,800 million in 1995 to RM4,800 million in 1998 [5]. This increase was attributed to a number of fiscal incentives introduced to promote the use of IT including the removal of sales tax on computers and components, and the granting of accelerated capital allowance for expenses on computers and other IT equipment.

The Malaysian government will continue to encourage wider applications of IT in order to increase efficiency, productivity and competitiveness of the economy. While IT applications in manufacturing, services, education and health will be promoted, IT in sectorial development will be accorded priority to ensure a coordinated approach at the national level [5]. According to the Malaysia Information Technology report Q2 2014 [6], the IT market increased to a value of RM16.9 billion in 2013, up 6.8% from 2012. Although there exist a notable downside of sales recorded in 2013, there will be other areas of strong growth in security software and services, outsourcing services, cloud computing and tablets; thereby capitalizing on the strong consumption story in Malaysia. By 2015, software spending is forecast to rise steadily to US$1.2 billion, with software Compound Annual Growth Rate (CAGR) for 2011-2015 in the region of 11% [7].

The Ministry of Science, Technology and Innovation (MOSTI) is the Malaysian ministry in charge of research, telecommunication and information technology. MOSTI revealed that the Malaysian government had launched a series of Malaysia Plans in various sectors covering agriculture, education, healthcare, infrastructure and ICT [8]. All these past and present national plans aimed to provide a sound platform for Malaysia to transform into a knowledge-based society and value-driven economy.

In the 6th Malaysian Plan (RMKe-6, 1991-1995), ICT was emphasized as an enabler mainly in the manufacturing sector [8]. This was further build upon with the introduction of National Information Technology Council (NITC). The primary function of the NITC is to ensure that ICT is well integrated in the socio-economic fabric of the nation. In short, there is still ample scope of growth for Malaysian SMEs, to improve, invest, explore and research into ICT.

ICT plays a key role in the 10th Malaysia Plan (RMKe-10, 2011-2015) [9]. The contribution of the ICT industry to Gross Domestic Product (GDP) is targeted to increase to 10.2% by 2015 as compared to 9.8% of the nation's total GDP in year 2009 [10]. Greater use of ICT will not only support the growth of the sector but also boost productivity and raise the nation's overall competitiveness. MDeC will take a leading role enabling SMEs to move from Capex (capital expenditure) to Opex (operating expenditure) with the aim of making ICT a necessary daily utility which is similar to electricity or water [10]. Other areas of interest in the 10th Malaysia

Plan are online cloud computing, creative multimedia (to make Malaysia a hub for animation, filmmaking and games), networking solutions (target for 75% household broadband penetration by 2015).

One of the areas of IT development which the Malaysian government could pay attention to is the business management process which provides tangible business results to the bottom line by continuous process improvement and variation reduction. A powerful quality improvement method is capable of boosting employee job satisfaction and increasing profits [11].

Many IT companies are now being assessed according to standards that have brought substantial profits to them; and at the same time utilize these standards to improve the quality of software products. According to Mohammad et al., [12], it is estimated that more than 900 improvement initiatives can be used to improve an organization’s performance. Most IT organizations in Malaysia adopt International Organization for Standardization (ISO) standards in managing quality of projects, processes, and procedures [12]. The ISO 9001 standard has been widely adopted and incorporated as a basis for self-improvement or internal-assessment for IT project management [12]. A survey conducted by the author (Section 2.2) revealed that ISO is the most commonly adopted quality improvement methodology (QIM) in the past but is facing decreasing popularity among the IT companies due to the shift of QIM selection in search for continuous improvements seeking for QIM that supports both Quality Control (QC) and Quality Assurance (QA) approach [13]. Hence, ISO is a past phenomenon for organizations which already have the basic business operational routines in place but striving to sustain long term improvements.

On the other hand, Six Sigma improves efficiency and effectiveness by identifying root causes and eliminating or reducing variations and defects to enhance customer and employee satisfaction, increase return-on-investment, market share and prepare the organization for the competitive global market. This is the reason why Six Sigma is one of the upcoming methodologies gaining in popularity amongst many organizations (IT and non-IT firms) [14-16].

1.2 Problem Statements

Despite more than 97% of the Malaysia SMEs in the IT industry adopted a QIM as a means of continuous improvement; projects delays, cost overrun, scope creep, customers’ dissatisfaction, not meeting user requirements, customer complaints, customer dissatisfaction, bugs, down time etc. are the common challenges faced by the top management. However, when it comes to implementing quality standards in the IT industry, most project managers face so many pressures to deliver systems and technologies which meet the organization's ever-changing needs that quality falls by the wayside. The IT industry as a whole has fallen short of delivering technology that people understand, reliable, usable and most importantly meeting business needs. Many of the problems occur because of the complexity of technology and the rapid pace of change which the current QIM is not capable to cope and tackle especially from the aspect of continuous improvement. Therefore, a mean of continuous improvements in the QIM implementation play an important role in delivering successful projects. Neither of these conditions is likely to abate; effective implementation and integration of single or hybrid set of QIM into an organization's business IT processes, IT Services and IT products has become increasingly crucial to long term survival and prosperity.

In most cases, the evaluation method of quality initiative is prevention-focused (i.e. Quality Assurance (QA) approach) where a set of well-established quality management system (i.e. quality on papers) are in place for its operational adequacy. Despite a customized assessment for its adequacy and periodic scheduled conformance audits for day-to-day operations routines, most top management of the SMEs IT companies face pressures and challenges to deliver end products and services within scope, within budget, meet user requirements; and most importantly within established technology performance and quality standards.

Due to time factor, the traditional QA approach no longer fulfils and satisfies company's business objectives as the evolving and demanding customer needs and expectations drives the IT companies to explore better ways to ensure continuous improvements. In the modern quality management, the project performance can be substantially improved by implementing and integrating systematic and structured approach of QIM which support QC and QA+QC approaches for quality and operational excellence to sustain long term improvements. The new approach of QC and QA+QC ensures that standards are rigorously enforced and embedded into the thinking and leaning cycle of entire organization's IT community. The main challenge of the shift of QIM from QA to QC and QA+QA lies in leveraging and incorporating the concept of QC and QA+QC into the critical components of an IT quality function. The approach of QC and QA+QC helps to define an IT quality function.

1.3 Research Background

The Six Sigma concept was introduced by Bill Smith in 1986, a senior engineer and scientist within Motorola's communication division, in response to problems associated with high warranty claims. This was the time when Six Sigma's term was first coined by Bill Smith (a Motorola engineer), leading to some dramatic quality improvements in the Japanese electronics industry [17, 18]. Since then, Six Sigma was developed at Motorola and perfected at companies like GE. Six Sigma has saved billions of dollars in waste, rework and reclaim costs. It has become a method for holistically measuring all aspects of the business enterprise.

Six Sigma originated from the manufacturing industry in mid-1980s by Motorola, and has since been adopted by quite a number of other manufacturing organizations including GE, Honeywell, Sony and Caterpillar. Other examples of industry areas are banking [19], healthcare (on delivery services management system [20, 21], efficacy of quality improvement initiatives [22], anticoagulation management process [23]) , software engineering (on process and product performance [24]), electrical engineering (on plasma cutting process optimization [25]), leisure service quality to enhance service quality and increase competitiveness [26], steel manufacturing industry [27], internet service provider to manage product quality and to increase customer satisfaction [24], retail bookstores to reduce shoplifting [28] etc.; including software development, mainly where customer service presence is relevant [29]. This clearly proved that Six Sigma indeed has great potential and is worth the effort and time to further explore and investigate.

In the life cycle of IT Project Management, there will always be unexpected and unplanned problems and questions that crop up throughout the project duration; it could be scope creep that delay the project and puts further strained on resources [30], lack of constructive testing which leads to an increase of reported bugs and further delaying the sign-off of User Acceptance Tests and more [31]. These were the “well-known” delivery obstacles that every project would face and indeed commonly happens among IT projects. These obstacles are affecting the quality of project outcomes which would further lead to customer dis-satisfaction.

The issue of “quality” in the business area of IT Product, IT Services and IT Processes from the customer view-point is the main concern of all project teams. Therefore, the greatest challenge of Six Sigma implementation in IT project management is the ability to measure the “quality” of IT Products, IT Services and IT Processes in return of better customer satisfaction. There is still ample room to explore Six Sigma implementation in the area of IT in Services (i.e. helpdesk, call centers), Products (hardware and software) and Processes. However, the quality measurement index of Six Sigma in these areas is always an issue for discussion. Hence, there is an urgent need to research the feasibility of Six Sigma Implementation for such areas of IT. To enhance the successful implementation of Six Sigma in the Malaysia IT industry, the author identified a need to create a general overview and gain understanding among IT organizations and IT specialists regarding the feasibility and possibility of implementing and integrating Six Sigma into the field of IT Processes, IT Products and IT Services.

Six Sigma is no longer a methodology solely for the manufacturing sector. An increase of Six Sigma adoption and implementation into the field of IT project management for medium-to-large scale organizations is observed. It is necessary to create a general overview and raise awareness among IT organizations and IT specialists (especially in the region of South-East Asia) regarding the feasibility and possibility of adopting and implementing Six Sigma into the field of IT in the three IT business areas: IT Processes, IT Services and IT Products; not limiting to a single sub-trade of IT related businesses.

Although there are contradicting views from the minority of Malaysian IT specialists seeing Six Sigma as burden of "a cost" and "a passing fad" from a survey conducted by the author (refer to Section 2.2.4) [13], this study will establish a Six Sigma implementation framework as a baseline for SMEs to better manage, control and track business performance and product quality. Furthermore, the study also extract and explore the best practices associated from "The Six Sigma Way" in different IT environments and project nature to develop detailed and comprehensive guidelines for managing Six Sigma IT projects.

1.4 Research Objectives

The aim of this study is to explore the possibility of integrating QC and QA+QC approaches through Six Sigma quality management standard to provide tangible and measureable business results by continuous process improvement to boost customer satisfactions. The theoretical principles and practices from literature reviews will be compiled and summarized into conference papers to gain understanding of Six Sigma implementation in the field of IT. The research objectives for this study are:

- **RO1**: To investigate current QIM adoption of IT organization in Malaysia and the awareness of Six Sigma implementation among IT Specialists.
- **RO2**: To identify decision criteria of selecting a suitable and applicable QIM for IT Company.
- **RO3**: To identify root causes of project delivery obstacles using Six Sigma approach especially in the exploratory case study approach.
- **RO4**: To conceptualize and develop Six Sigma Implementation framework for implementation and integrating in Malaysia IT companies in the field of IT Project Management.

The list of research activities in achieving the research objectives are:

- To conduct a literature review on various quality management improvement methodologies of IT organizations in the areas of IT Services, IT Products and IT Processes; and compare the respective strengths and weaknesses for each initiative;
- To conduct literature survey on quality management improvement methodologies applied in the Malaysian SMEs IT organizations , in the areas of services, products and processes; and investigate the best practices;
- To conduct a literature survey and define a means of selecting, prioritising and scoping improvement opportunities as well as the means of measuring the effectiveness and efficiency of implementing Six Sigma in IT services, products and processes in Malaysia;
- To investigate, measure and apply Six Sigma techniques to the IT project management area of services, products and processes for case companies;

- To conduct exploratory case study (in collaboration with partially or complete implementation of Six Sigma organizations) to measure the effects of implementing and integrating Six Sigma in IT services, products and processes; collective lessons learned through case study will be recorded and analysed for framework formulation purposes.
- To determine the measurement index and feasibility approach of Six Sigma implementation and integrating Six Sigma in the field of IT Process, IT Product and IT Service;
- To develop a prototype framework and a set of guidelines in preparation for Six Sigma implementation and integration;
- To implement the developed Six Sigma framework on a selected IT organization to improve services, products and processes and attain sustainable development in an acceptable time frame;
- To extract and explore the best practices associated from "The Six Sigma Way" in different IT environments and project nature to develop detailed and comprehensive guidelines for managing Six Sigma IT projects;
- To further refine and revise on the measurement terms and prototype framework model as necessary based on the collected and compiled results.

1.5 Research Hypothesis / Research Question

Six Sigma is an internationally recognized management process focused on producing high quality products or services to meet a customer's satisfaction that is near "zero defect" [32]. Six Sigma represents a philosophy and means of doing business in a way that effectively measures process, service and product performance, identifies variation, applies a complete set of tools to ensure consistency and enhances customer satisfaction [33-35].

Due to evolving customer needs and expectations, increasing IT knowledge of direct and indirect end users, innovation in technology and others revealing factors, IT companies have no choice but to explore better ways (i.e. quantitative and qualitative) with a measurement index for their end products, processes and services [36]. This is to ensure continuous improvement as a survival factor for companies to stay competent in the red-sea market and yet has the ability to explore opportunities in the blue-sea market. Hence, it is important for companies to incorporate a proper measurement index of quality standards into the company's overall operational procedures.

In view to investigate, measure and apply Six Sigma techniques to the IT project management area of services, products and processes, there is a need to understand its role as a new improvement and integration method that could benefit most of the SMEs in Malaysia. Since Six Sigma is a philosophy that emphasizes process and procedural improvement of the project context, the following are questions the author aims to explore in this study:

- **RQ1**: How could the "project quality" be addressed and measured?
- **RQ2**: What are the possible quality metrics to benchmark for future IT projects in reducing the learning curve and yet improving the project quality?
- **RQ3**: What are the driving factors for scope creep, project delay and project cost overrun?

- **RQ4**: What are the problems and challenges anticipated during project life cycle for IT Product, IT Process and IT Services?
- **RQ5**: What are the activities involved in IT Project Management?

The research hypotheses for this study are:

- Hypothesis 1: This study is based on the hypothesis that implementing Six Sigma as a QIM in the field of Malaysian IT industry will improve the overall project quality and customer satisfaction.
- Hypothesis 2: If there exist a currently adopted QIM, integrating Six Sigma into existing QIM will improve the quality of IT Products, IT Services and IT Processes.

1.6 Contributions of the Research

Currently, there are many SMEs in Malaysian IT industry facing difficulties in winning tenders due to a lack of knowledge or lacking proof in the area of quality management [37]. Main contractors prefer to award contracts to companies with a quality management background [37]. Hence, it is a painful threat for most SMEs without quality certification or without quality management skills, knowledge and experience. In most cases when the proposal/tender has been shortlisted at the final stage, it is always the readiness of "quality awareness" issues which shut the door on winning the bid. This aggressive market pressure and trend have driven SMEs to acquire necessary skills and knowledge on the area of quality management. An empirical research by Kuei & Madu [37] revealed that in order to ensure product outputs are aligned with quality control, the key ingredient is to have vendor-supplier alignment in quality improvement methodology (QIM) too (i.e. Six Sigma). This implied that the adoption of QIM is a chain process (or top down approach) starting from the development team to supplier.

The roadmap to quality improvement methodology selection provide a clearer and easier way of selecting a suitable and applicable methodology that fits an organization's objectives and culture prior to investing much time, money and resources. Besides, this study traces the evolution of QIM in Malaysia's Information Technology (IT) industry in the past, current and future; and highlights some of the thoughts of researchers who have contributed to the science and practice of quality, and identifies leading methodologies in use today. Some of the misconceptions and mistakes leading to quality system failures will also be examined and discussed. A general overview of different types of QIMs available for IT businesses is discussed allowing appropriate selection leading to maximizing business advantages, enhancing product quality, improving process routines and increasing performance earnings.

The framework and guidelines produced by this research will serve as a basis for companies which have an interest or indeed needs to incorporate quality standards and measurement into their area or sub-area of businesses operations. As a result, the learning curve could be shortened and the company can divert their resources to sustaining market position and creating better opportunities to achieve long term goals. Furthermore, this roadmap framework has taken a step further to understand the interrelationship and the correlation between IT Processes, IT Products and IT Service; and how they affect quality; and thereby get closer to identifying the importance of IT Processes which is truly a vital segment to the quality of IT Products and IT Services.

This study is in line with Wawasan2020 where Malaysia targets to increase the percentage of "high caliber" entrepreneurs and technopreneurs by 2020 [8, 9]. Malaysia aims not only to show sharp rises in business entity entries, but also to develop awareness and capability of entrepreneurs and technopreneurs to compete and survive by continuous process improvement.

In summary, this study provides an overall view on the best practices and lessons learned from QIM adoption and implementation from the literature review and case studies carried out. The final output and contribution of this study relates to the awareness and feasibility of implementing and integrating Six Sigma methodology into different working environments (i.e. into the business area of IT Products, IT Services and IT Processes), different business scale and different business operations. Successful quality improvements were explored and achieved in various aspects of IT project management context especially in fostering improvement in customer satisfaction, operational effectiveness and efficiency as well as human resource utilization.

1.7 Limitations and Key Assumptions

The following are the limitation identified for this study:

a) The willingness of the respondents (i.e. organizations and IT personnel) to participate in the survey. This is to reassure sampling choice is representative.
b) The willingness and ability of the IT organizations to voluntarily participate in the Six Sigma case study. The project information gathered and obtained during the project investigation needed to ensure its privacy and confidentiality. This may limit the author investigation covering the three business areas
c) The case study was conducted at real-life case study IT companies where flexibility of time frame is restricted and bound by schedule availability of the Project Manager and the turn for next around of observation or data collection to validate the improvement actions.
d) The nature of case study approach will always be prone to biases, mis-interpretation of data, skew sampling choice, confidentiality and etc. Every attempt remove such biases in the research will be taken to carefully minimize the occurrence of these errors by validating the findings from the data collection outcomes.
e) Thus an ethical protocol was developed and strictly adhered to; this limited the use of the information collected.

1.8 Research Design and General Methodology Approach

In order to determine the measurement index and feasibility approach of Six Sigma implementation and integrating Six Sigma in the field of IT Process, IT Product and IT Service; the mixed-method approach was employed to understand the sample research environment, operational workflow, organization's culture, and others relevant variables was finalized. Prior to this study, an extensive literature review among different categories of IT business areas (i.e. IT Products, IT Services and IT Processes) were carried out and discussed to reach a conclusion that there exists a strong relationship between IT Processes, IT Products and IT Services; and the ability to properly manage one segment (IT Processes) will result in overall performance improvements [38]. As a result, the implementation of Six Sigma in IT industry has been segmented into the category of IT Product, IT Process and IT Services. The thesis outline for this study is further elaborated in the next section.

1.9 Outline of Thesis

Chapter-1 provides an introduction to the background of the research problem. This chapter outlines the research objectives, hypothesis and research questions, problems, significant contributions and motivation behind the proposed research. It also provides an outline of the thesis and boundaries of the research.

Chapter-2 starts with an overview and critical analysis of different types of QIMs in the field of IT industry. A comparison of each QIMs to its objectives, aims, advantages, criticisms and its rational for adoption. It is important to better understand the capability and compatibility of each QIM in dealing with project quality. This chapter also presents the results obtained from the survey research conducted with Malaysian SMEs IT companies. By leveraging the literature and survey outcomes, section two outlines a high level roadmap to QIM selection for IT related and non-IT related businesses, the evolution of QIM in Malaysia's IT industry and the shift of QIM selection focusing both aspect of qualitative and quantitative in quality measurement metrics. A set of significant theoretical evidences of different combination matrix of QIMs integration in search of quality focused-extension into both QA and QC were discussed in section four. A new emergent shift paradigm of Six Sigma as a new QIM adoption or integration with other QIM in the field of IT are discussed in this chapter too.

Chapter-3 presents an overview and introduction to the history and historical development of Six Sigma. This chapter also extends Six Sigma literature related to its belt hierarchy system, concept and logic, sigma level determination and calculation, methodologies, tools and techniques. The following section describes in detail the five-phase improvement cycle of Six Sigma DMAIC, Design for Six Sigma (DFSS) and Six Sigma Roadmap case study approach in the context of process improvement and process design/redesign effort. In the next section, a comparison of Six

Sigma with other QIMs is discussed and a summary of similarities and differences among the QIMs are achieved. The following section outlines a new understanding of relationship between IT Process, IT Product and IT Services is discussed to raise the awareness of Six Sigma as a QIM in the IT industry beyond the manufacturing sector. Last but not least, a list of common myths are discussed and demystified with literature evidences to gain better understanding to view Six Sigma as a powerful, discipline and structure problem solving methodology.

Chapter-4 discusses different types of research methodology and research approaches for a research study; the appropriateness of the research design, the population, assumptions and limitation. This chapter also includes the discussion of the chosen methodology and design and its rationale for adoption. The following section explains the cases selected for assessment, the materials, instruments and Six Sigma tools and techniques applied in the exploratory case study. A section explaining the research workflow of the exploratory case study was discussed; outlining how the use of different research approaches was conceptualized and developed into a framework. This chapter concludes with a summary of the research methodology. The following chapters present the results of three exploratory case studies using the Six Sigma way.

Chapter-5 presents the results obtained from the exploratory case study using the Six Sigma way conducted with case company SYNDES Technology Sdn. Bhd. This case study covers the business area of IT Product and IT Process implementing the design/redesign approach in search of better way to improve product and process quality. The Six Sigma improvement opportunity lies in the customization of System Development Methodology (SDM) to better utilize its team members; as well as better handling and sharing of business and technical knowledge across team members. This chapter outlines in detailed each phase of the design/redesign process and progressively demonstrates how SYNDES achieve in cost reduction, productivity improvement, cycle time reduction, defect reduction etc.

Chapter-6 discusses another exploratory case company of IS Support in the business area of IT Service and IT Process. This chapter demonstrates how Six Sigma as a QIM can help to improve the quality performance of front desk services; and to maximize the usage of the HMS in managing, tracking and controlling all IS front desk services. The efforts to position the case company for greater front desk efficiency and customer satisfaction using the Six Sigma way has led to concrete improvements in incident satisfaction survey, queue-waiting time reduction, HMS utilization improvement and positive cultural change.

Chapter-7 shares the success story of Company-C from the category of IT Service and IT Process implementing Six Sigma to meet the contractual performance of service level agreement (SLA). By focusing on the process improvement in engineers' utilization and distribution among project accounts; the change has contributed to major improvements in SLA achievement, better resource utilization and saving of operation cost. The main contribution of this exploratory case study is the formulation of a prediction chart to forecast ticket volume for better SLA performance. The success story of the three case companies has proven the the feasibility, validity and usability of the framework in helping IT companies to replace reactive habits with a dynamic, responsive, proactive style of management in search of quality excellence.

Chapter-8 is an explanatory and argument synthesis summary which discuss a number of sources and draws relationships between them. Facts are presented in an objective manner; judgements are made and conclusions are drawn about the quality and validity of these sources. The discovery of relationship among these sources creates a new understanding of information and ideas which later combined to conceptualize and develop a Six Sigma Implementation framework for implementation and integrating in Malaysia IT companies in the field of IT Project Management. This makes the proposition about the framework formation clearer, convincing and relevant with supported basis from both quantitative and qualitative methodology. The final components of assessment for the framework is discussed and presented.

Chapter-9 concludes the study by re-stating the research purpose, research objectives and mapping of research objectives with relevant evidences from the synthesis summary chapter. It also addresses the research questions and research hypothesis, presents the research contributions and its implications. Lastly, this chapter discusses the limitation of the study and its direction for future research.

Chapter-2 Quality Improvement Methodologies

2.1 Literature Review on Quality Improvement Methodologies

2.1.1 Different Types of Quality Improvement Methodology

There are various approaches to implement quality improvements. Organizations aim for a management standard which is capable of providing their customers with quality assurance on products or services they produce via continuous process improvement. When quality programs constantly change, it is difficult to develop a quality system that can show significant results.

Quality standards are intended "to provide a generic core of quality system standards applicable to a broad range of industry and economic sectors". A major purpose of quality management is "to improve the systems and processes so that continual improvement of quality can be achieved" [39]. The standards describe what elements quality systems should encompass but not how a specific organization should implement these elements. Many software suppliers try to accomplish software process improvements by implementing a quality system [39].

Quality Management (QM) is a way of thinking about the management of organizations and is an alternative to management by control. It is a comprehensive way to improve total organizational performance [40]. QM has long been established as an important strategy for achieving competitive advantage. Traditional quality initiatives (statistical quality control, zero defects and TQM) have been the key initiatives for many years. Six Sigma is a recent quality improvement initiative that has gained popularity and acceptance in many industries [32].

QIM plays an important role in a quality management system. There are many types of quality management methodologies being adopted and implemented in organizations with different backgrounds across different industries. These QIMs have been discussed and reviewed by various researchers, and the findings from these reviewed papers [29, 34, 39-47] presents the most widely used QIMs for today's problem-solving and quality improvement purposes. They are: (1) Total Quality Management (TQM) ; (2) International Standard Organization (ISO 9000); (3) Capability Maturity Model (CMM/CMM-I); (4) Software Process Improvement and Capability Determination (SPICE); (5) Balance Scorecard; (6) BOOTSTRAP; (7) Information Technology Infrastructure Library (ITIL); (8) Personal Software Process (PSP); (9) Lean-Sigma ; (10) Six Sigma and (11) Theory-Of-Constraints. The author has significantly discussed and reviewed the details of each QIMs in year-1 and year-2 progress report, and hence a summary for each QIM will be tabulated in Table 1.

Table 1 Summary of Quality Improvement Methodologies

Quality Improvement Methodology (QIM)	What is and Why this QIM?	Criticism
Total Quality Management (TQM)	• TQM is a continuously evolving management system consisting of values, methodologies and tools, with the aim to increase external and internal customer satisfaction with a reduced amount of resources [40]. • The aim of TQM management philosophy is to change corporate cultures from a passive and defensive culture to a pro-active and open culture. • The basic TQM principles increased customer satisfaction, continuous improvement and everybody's participations are applied everywhere in the organization. • TQM promote a work culture where everybody is proactively working in reducing waste and in helping each partner (internal and external) [41]. • TQM is a good approach to improving the competitiveness, effectiveness and flexibility of a whole organization and it ensures the management adopts a strategic view of quality [49]. • TQM always strive to satisfy customer needs and wants at lowest possible cost through extensive involvement of the organization's human resource. • TQM has the flexibility to integrate with Six Sigma as enablers of Business Excellence assisting in the strengthening of an organization's competitive position by soliciting, heeding and fulfilling the VOC (voice of customer) either through improvement or design of products, processes and services that contribute to both customer and organizational value [50].	• It was reviewed by Andersson et al., [40] that about **one-fifth, or at best one-third**, of the TQM programmes in the US and Europe have achieved significant or even tangible improvements in quality, productivity, competitiveness or financial results. • Different views (due to a vague definition of TQM) concerning what TQM is has led to different opinions about what TQM should result in [40]. • By the late 1980s, TQM was reported to have been ineffective due to lack of results, implementation problems, and failed TQM efforts [48]. The decline popularity of TQM has caused a natural transition of quality improvement methodology adoption from TQM to Six Sigma [48].
International Standards of Organization (ISO)	• ISO head-quartered in Geneva, is a worldwide federation of national standard bodies (ISO member bodies, such as SIRIM, SISIR, etc) which are responsible for creating standards for each member country. • ISO9000 is a family of management standards which deals with the fundamentals of quality management systems, including the eight management principles on which the family of standards is based [51]. • **ISO 9004** is a guideline for the quality management of a manufacturer [52]. In order to be optimally effective, the quality system of a supplier must be adapted to the requirements of the customer and the product. • ISO 9001, 9002 and 9003 were defined for proving the quality system of a supplier to the customer. **IS0 9001** is the most comprehensive of the three standards which covers all phases of a product life cycle from design up to installation and service and it deals with the requirements that organizations wishing to meet the standard have to fulfill. • **IS0 9002** and **IS0 9003** contain models for external quality assurance purposes in production and installation or final inspection and test. Both are only concerned with partial parts of the product life cycle and are also less stringent in some respects if compare with ISO 9001. • Over a million organizations worldwide are independently certified, making ISO 9001 one of the most widely used management tools in the world today [53]. The ISO 9000 standards are intended to provide a generic core of quality system standards applicable to a broad range of industry and economic sectors [39]. The standard is suitable for large bureaucratic organizations where there is a central command from top to bottom and where each individual has a structured role [54].	• **Significant amount of time, money, effort and paperwork required for ISO registration**. The average time needed to implement an IS0 9000 quality system is 1.5 years [39], a company designs a quality system "from scratch" would take at least 2 years [39]. ISO implementation mandates all managers and software developers writing reports, reviewing documents and attending workshops. Besides, a lot of preparation is needed for the annual auditing event [54]. As a result, the costs of implementing and certifying a quality system does not correlate with the size of the company [39]. • **ISO is assumption based.** The IS0 9000 family is based on the assumption that all work is accomplished by a process [39]. If the process is being followed or applied in accordance to a quality manual, everything will go well and customers are happy. This would end up with a so called "paper system" that does not have much or any impact with the way to run a business operation, commented by ISO's Roger Frost [55]. ISO 9000 certification may be a means to impress customers, but by itself certification does not necessarily correlate with improved quality [51]. It could be a product or service provider that conforms to all the ISO criteria but yet delivering product or service which meets customer needs. • **ISO is prone to failure when a company is interested in certification before quality.** Many companies use ISO certification as a means of a strong marketing argument and regard it as a prerequisite for increasing sales figures

<table>
<tr><th>Quality Improvement Methodology (QIM)</th><th>What is and Why this QIM?</th><th>Criticism</th></tr>
<tr><td></td><td>

- The ISO family of standards is the only international standard that addresses systemic change [39].
- Most of the Software suppliers usually choose the ISO 9001 as a basis for certification to satisfy customers' requirements, a general consideration that has greater weight than the internal desire to improve quality [39, 51].
- The advantages of a company competitively implementing ISO are: Create a more efficient, effective operation; Increase customer satisfaction and retention; Reduce audits; Enhance marketing; Improve employee motivation, awareness, and morale; Promote international trade; Increase profit; Reduce waste and increase productivity [30].
- Hass et al., [45] has proven a positive correlation between the maturity in software development processes and the holding of an ISO 9001 certificate covering software development.

<table>
<tr><td>ISO 9000 Series</td><td colspan="3">Guidelines for Selection and Use</td></tr>
<tr><td>ISO 9004</td><td colspan="3">Quality Management and Quality Systems Elements Guidelines</td></tr>
<tr><td>ISO 9001</td><td colspan="3" rowspan="3">Quality Systems, Models for Quality Assurance</td></tr>
<tr><td>ISO 9002</td></tr>
<tr><td>ISO 9003</td></tr>
<tr><td rowspan="2">Product Phase</td><td colspan="3">ISO Standard</td></tr>
<tr><td>9001</td><td>9002</td><td>9003</td></tr>
<tr><td>Development</td><td>√</td><td></td><td></td></tr>
<tr><td>Design</td><td>√</td><td></td><td></td></tr>
<tr><td>Production</td><td>√</td><td>√</td><td></td></tr>
<tr><td>Final Inspection</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Test</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Installation</td><td>√</td><td>√</td><td></td></tr>
<tr><td>Service</td><td>√</td><td></td><td></td></tr>
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[39]. This action depicts the initial objective of ISO of being a continuous process improvement and dignity to stay competent and conformance to customer needs is questionable [51].

- **Competition among certifying bodies**, leading to a softer approach to the defects noticed in the operation of the Quality System of a firm. Though the set of certification guideline used by independent certifying bodies are the same, the determination of the level of conformance and nonconformance varies among certifying bodies.
- **High Level of Human Resource Commitment.** All employees must attend training on ISO 9000 and appreciation course, quality policy and procedures manual contents.

</td></tr>
<tr><td rowspan="2">Capability Maturity Model (CMM) and Capability Maturity Model Integration (CMM-I)</td><td>

- CMM is a service mark registered with the U.S. Patent and Trademark Office by Carnegie Mellon University (CMU).
- The aim is to guide software organizations in selecting process improvement strategies by determining current process maturity and identifying the issues most critical to software quality and process improvement [56].
- Though the CMM comes from the field of software development, it is adopted as a general model to aid in improving organizational business processes in diverse areas such as software engineering, system engineering, project management, software maintenance, risk management, system acquisition, information technology (IT), services, business processes generally, and human capital management [57]. The CMM has been used extensively worldwide in government offices, commerce, industry and software development organizations.
- The path describes key practices at each of the five levels. The description includes a number of goals at each level.

</td><td rowspan="2">

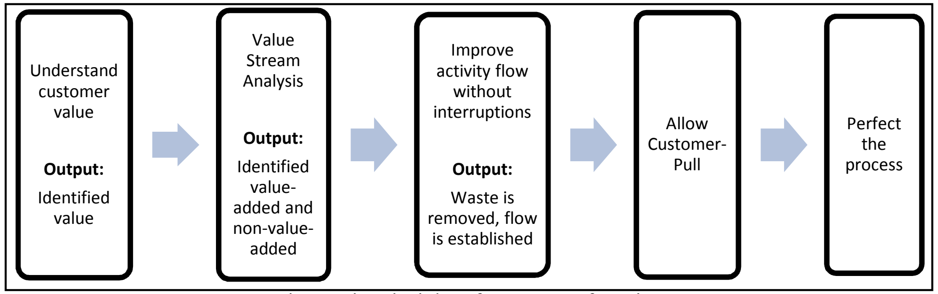
- CMM/CMM-I only suggests "what to do" to the development team but does not give any guidelines for "how to do it" [58]; where software engineers do not know how to handle and solve problems due to the lack of procedures and means to improve their processes at organization level [59].
- Achieving the highest CMM-I maturity level demands much effort and dedication of all people in different level in the organization [60]. A CMM evaluation reveals that only two percent of organizations have achieved level-4 or level-5; nearly 62 percent are at level-1. Also, the process of achieving level 3 takes four years on average, which shows that progression through CMM maturity level is both time-consuming and difficult [61]
- CMM is seen for large businesses and it is rather difficult to understand, interpret, use and apply in small businesses. CMM also needs to be more flexible and has the ability to scale down it requirements to suite small business [62].

</td></tr>
<tr><td>

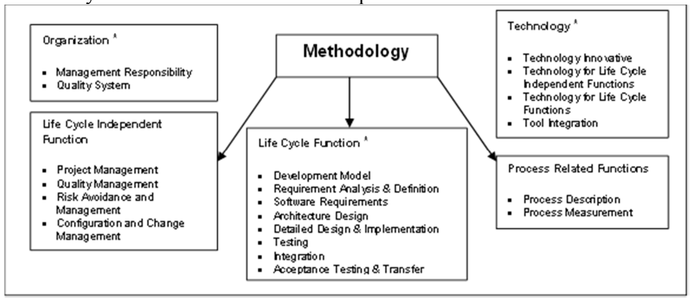
- CMM is a framework characterizing a path for software process improvement. It is a systematic approach that describes key practices at each of the five levels.
- According to Hass at al., [45], for an organization to get from level-1 to level-2, an organization has to achieve the goals for six software processes, the so-called key process areas (Requirements Management, Software Project Planning, Project Tracking and Oversight, Subcontractor Management, Configuration and Change Management, and Software Quality Assurance).
- CMM level-3 begins with process mapping and CMM level-4 deals with data analysis.
- CMM level-5 is the foundation of Six Sigma and it is essentially the beginning of a data-driven

</td></tr>
</table>

Quality Improvement Methodology (QIM)	What is and Why this QIM?	Criticism
	improvement phase. Six Sigma is a CMM level-4 and level-5 activity which urges organizations to think of continuous improvement and technology changes. However, organizations operating at CMM level-5 do not guarantee that it produces Six Sigma quality software. • Over times, the CMM has been superseded by CMM-I. CMM-I is capable of measuring the maturity level of the whole lifecycle of application development including addressing practices that covers the products' lifecycle from inception through to deliver and maintenance [63] • The CMM-I model has proved useful to many organizations such as IBM Australia Application Management Services, where CMM-I help in reducing cost effectively [64].	
Information Technology Infrastructure Library (ITIL)	• ITIL presents a comprehensive set of guidelines for defining, designing, implementing and maintaining management processes for IT services from the people (in the organization) as well as from a technical systems perspective. • The best practices from ITIL's framework can be used to assist organizations as their needs and technology evolve around fine-tuning of processes [65]; benefiting from the value-added activities (i.e. be more agile with their responses, define standards, implement new technologies, adopt new trends, regulate compliance, and improve the quality of IT services) and in terms of demonstrating companies' value via ROI [65]. • The list of benefits (direct and indirect) from ITIL implementation are [66]: • Superb and reliable quality of IT services were provided to customer which differentiate the company in the competitive markets, as well as to improve company's business model • Daily routines and procedures were improved; knowledge-based information helps to solve lots of incidents on first level support and leave specialists free from solving simple and repetitive issues. • IT audits allows in-depth feasibility and functionality analyses of the software and its possibility to integrate with current IT infrastructure.	• ITIL dictates to organizations "what they should do" but is not clear about "how they should do it" [44]. A survey by Noel Bruton (2004) revealed that 77% of the surveyed respondents were either agreed or strongly agreed that "ITIL does not have all the answers". This is due to ITIL not defining how "things" should be accomplished and does not address who within the organization is going to be in charge of implementing each process [65]. • The pool of guidelines resides in the "library" may be too general to be applied in IT services due to the dynamic nature of the IT businesses. • There is always a confusion of "company directive" where IT staff used to listen to their superiors (i.e. Project Leader (PL) or Project Manager (PM)) instead of following newly implemented ITIL processes [66]. As a result, the decision made by PM/PL somehow superseded the best-practices defined in the ITIL processes. • ITIL is just a set of guidelines use to align a company's IT services with the needs of the business. ITIL is neither a method for measuring quality or identifying and completing process improvement projects, nor guaranteeing service quality within an IT organization. ITIL is not a well-rounded solution as it does not focus on specific industry segments, it does not mandate any workflow design or process, and it does not promote any particular organizational structure or management style [65]. • Because of its primary focus on service management, ITIL has limited capability and utility in dealing with poor-designed enterprise.
Theory-Of-Constraints (TOC)	• TOC is a system improvement methodology where a group of interdependent links work together toward the overall goal [46]. The system itself is the chain and the constraint is a weak link. • The performance of the entire chain (system) is limited by the strength of the weakest link. Therefore by focusing on constraints, TOC aims to produce positive effects on the flow time of the product or service through the system. • The "constraint focused" method neither requires intimate knowledge of data analysis nor require a large number of people understand the elements of the system. • TOC requires only to be understood by a few people with the power to change things. The value added workers do not need to have an in-depth understanding of improvement methodology. The effort can be localized with minimum involvement of the workforce [46].	• Linhares [67] from the Getulio Vargas Foundation, has shown that the TOC approach to establishing an optimal product mix is unlikely to yield optimum results
SPICE (Software Process Improvement	• SPICE is known as a set of technical standard documents for the computer software development process and related business management functions. • IT addresses all the processes from the phases of planning, managing, overseeing, controlling and	• ISO/IEC 15504 is not available as a free download but must be purchased from the ISO. • CMM was created much earlier than SPICE and CMM reached the critical

Quality Improvement Methodology (QIM)	What is and Why this QIM?	Criticism
and Capability dEtermination)	improving. • The first version is exclusively on software development processes. It was expanded to cover all related processes in a software business such as project management, configuration management, quality assurance and etc. • SPICE can be used in the context of "Process improvement" and "Capability Determination (which is evaluation of supplier's process capability)". • SPICE provides a standard for assessing the organization's capacity to deliver at each of these stages. In particular, the reference framework of ISO/IEC 15504 provides a structure for defining objectives, which facilitates specific programs to achieve these objectives.	'market' share before SPICE became available. Later, CMM has subsequently been replaced by the CMM-I, which incorporates many of the ideas of ISO/IEC 15504, but also retains the benefits of the CMM. The benefits of CMM/CMM-I clearly outweigh SPICE which made SPICE difficult to apply in a service management context.
Lean Production	• Lean Manufacturing or popularly known as Lean Production System or Lean Thinking or Toyota Production System (TPS) or Total Productive Maintenance (TPM) • It is a systematic approach in identifying and eliminating waste through continuous improvement, with the flow of products at the pull of the customer in pursuit of perfection. The main elements contributing to the elimination of non-value-added activities such as excess production, excess processing, delays, transport, inventory, defects and movements [40, 68, 69].  Five Basic Principles of Lean-Manufacturing • The key that guarantees the success of the Lean-manufacturing is the rigid specifications and the schedule of the processes, activities, connections and production flow. The system generates pressures and challenges continually for the processes to reach a higher performance level, towards continuous innovation and improvement [68]. • Lean stimulates the managers and collaborators to engage in the experimentation (shop floor operations) that is thoroughly recognized as the mark of a learning organization [68]. • The improvement areas as a result of Lean can be clearly seen in *operational improvements* (reduction of lead time, increase in productivity, reduction in work-in-process inventory, etc.), *administrative improvements* (reduction in order processing errors, streamlining of customer service functions so that customers are no longer placed on hold, etc.) and *strategic improvements* (reduced costs, etc.)	• Lean requires a stable platform, where scale efficiency can be maximized. Highly dynamic conditions cannot be dealt with, as there is no room for flexibility due to the focus on perfection, which is always a function of particular market conditions at a certain period of time [40]. The leanness in itself leads to reduced flexibility and less ability to react to new conditions and circumstances [40] • LPS has been acclaimed as the origin of the spectacular performance of Toyota as a manufacturer and their practices have been introduced in all the companies' processes. Lean has been criticize on its' originality; Lean Production is a production philosophy which tries to combine the principles of craftsmanship with mass production. The Five Basic Principles of Lean-manufacturing resemble very much the well-known quality improvement process developed by Motorola in the period 1983 to 1989 (called the process of "The Six Steps to Six Sigma") [41]
Six Sigma	• Six Sigma is a business management process that provides tangible business results to the bottom line by continuous process improvement and variation reduction [11]. It is used to identify and eliminate defects, waste and quality-control problems. It is a powerful methodology that boosts employee job satisfaction and increase profits [70]. • It provides a discipline to guarantee that one will work on the right problem, the root-cause will be	• Six Sigma has been criticized on the overlapping of tools, techniques and methodologies over other improvement initiatives. There are much overlapping in tools and techniques used in Six Sigma which have been used in TPS and SPC twenty-five years ago. • Six Sigma is just another repackaged quality trend that will come and go. It

Quality Improvement Methodology (QIM)	What is and Why this QIM?	Criticism
	identified and the best solution will be determined and implemented [71]. • It increases quality by reducing process variability to the point where a process yields less than 3.4 defects per million opportunities (DPMO) aligning with customer's expectation and providing high financial returns (or high payback) [71, 72] • **Six Sigma Approach** enables increased outputs and improved quality by reducing variation and optimizing processes [47]. • Six Sigma is an approach that can be of value in the development of solutions that jointly optimize multiple bottom lines which serve critical societal and operational functions. If intelligently applied, Six Sigma can assist in honing the missions of mercy or service, product and process because at a very fundamental level, Six Sigma is about changing an organization's culture and the way things are done [50]. • Six Sigma is a performance improvement approach (attacking at least one of the Cost, Quality, Delivery, Satisfactory, Sustainability measurements for improved competitiveness) [47, 77] which stresses the application of statistical and problem-solving tools and techniques in a methodical and systematic fashion to break through improvements with dramatic impact on the bottom-line results.	was inferred that the Six Sigma creator deliberately copied tools from Lean manufacturing, among other quality systems and simply "**re-branded**" these tools as Six Sigma [34, 73, 74]. • Criticism of quality target of 3.4 parts per millions (ppm) looks too severe to "cope" [47]. If the conditions change, the "operator" begins to perform differently, or the customer changes the quality requirements. • Six Sigma was criticized as being "Prescriptive" when one inaccurately believes that the same approach and tools are used by different business scale (i.e. design, manufacturing and assembly lines) [47]. • Criticism of having low tolerance for risk and difficult to implement innovation. Six Sigma cannot be implemented in vacuum but multiple methodologies are needed to support the enterprise strategy [65]. Six Sigma requires the organization to focus and direct its resources on operational excellence and perfection. • Criticism of taking much time and effort to realize the benefits of Six Sigma. There are companies that may put their Six Sigma initiatives to a halt if it takes a long time to realize tangible bottom-line benefits [75]. • Criticism of Six Sigma has little focus on understanding the human factor and too much focus on training people in tools and techniques, i.e. how to build the right company culture [41]. Understanding of human factor is the key ingredient in building a company's culture, ultimately Six Sigma is all about changing an organization's culture and the way things are done. • Criticism of Six Sigma often disconnected from shop floor as projects often take months to finish. The program creates elite Black Belts (BBs), who are frequently disconnected from the shop floor [76]. This left the warrior team having to put a "full stop" to shop floor activities.
Lean-sigma	• The concept of **Lean-Sigma** is to harness the strength of both Lean and Six Sigma. The Lean-Sigma approach is particularly good if an organization is in risk of receivership due to falling customer sales as a result of poor quality [47]. • Lean-Six Sigma integrates the Lean strategy and Six Sigma to avoid resource waste and to eliminate problems caused in management, manufacturing and production processes [60]. • A combination of Lean and Six Sigma has a positive impact on employee morale, inspiring change in the workplace culture because the teams see the results of their efforts put to work almost immediately [76]. • The Lean-Six Sigma engenders a greater sense of affinity amongst the workforce towards delivery of a quality product, and the organizations strive for its' notion of 'Achieving Competitive Excellence'. Though Six Sigma and Lean are not mutually exclusive, both are mutually supportive in that they complement each other's shortcomings: Six Sigma's apparent lack of people orientation and Lean is over-indulgent to people oriented team-based continual improvement efforts [77].	• Left Brain Thinking versus Right Brain Thinking. Six Sigma and Lean are being grouped as the "left brain tools" by Tony [34]. Six Sigma focuses on the use of statistical techniques and other "left-brain" tools such as Failure Modes and Effects Analysis (FMEA). Lean training is also often mainly founded on left-brain thinking. This may be both the great strength and the great weakness of much of Six Sigma and Lean methodology. • Cost Down Issue. There is always a lacking of formal link in policy deployment with Lean-Six Sigma. However, the major driver in Lean-Sigma project selection process is all about "cost down"; where the importance of fulfilling and surpassing customer expectations in project selection is affected by "costing". The issue here is that cost represents an important aspect of process efficiency – but does not, in itself, answer the effectiveness question as to whether you are providing the right product or service [34].

<table>
<tr><th>Quality Improvement Methodology (QIM)</th><th>What is and Why this QIM?</th><th>Criticism</th></tr>
<tr><td rowspan="2">BOOTSTRAP</td><td>The BOOSTRAP methodology is based on the Capability Maturity Model (CMM) and was developed by the Software Engineering Institute (SEI). It has however been extended and adapted to include guidelines from the IS0 9001 family of standards and the European Space Agency (ESA)'s PSS-05 software development standard [44, 45].
There are many SPI programs implemented cross many organizations and the role of BOOTSTRAP Institute is to educate and to grant licenses to companies. BOTSTRAP is a frequently used and successful methodology for improving the software process [44].</td><td rowspan="2">Although BOOTSTRAP is partly inspired from IS0 9001, it is not surprising that the process areas called Quality System and Quality Management are very different for the two methodologies [45]. This is proven by a study conducted by Hass at al., which revealed a poor correlation between the requirements in BOOTSTRAP for Project Management and the IS0 9001 standard [78].
Below shows the BOOTSTRAP model and there are three additional areas (Organization, Technology and Life Cycle function) in comparison to CMM. BOOTRAPS uses five level scaling points in determining an organization's maturity level and each scale includes quartiles on each level.

</td></tr>
<tr><td>BOOTSTRAP assessment can be carried out on any software provider organizations according to the BOOTSTRAP methodology. The week long assessment activities includes a pre-meeting, an opening meeting, a final meeting and delivery of an assessment report. The purpose of the pre-meeting is to brief the assessors on the organization, and the opening meeting is to give a general introduction of the BOOTSTRAP model and method to all participants (involved in the assessments). The assessment requires at least two licensed assessors conducting interviews and questionnaires. The detailed questionnaires are directed to both the SPU (Software Producing Unit which is equivalent to the management of the organization) and a selected project.
At the final meeting, the preliminary results of the assessment are presented. These results are subsequently further analyzed and a final report is produced. The maturity profile of a SPU can be derived using an algorithm from the BOOTSTRAP methodology and information gathered during the interviews and questionnaire. The maturity profiles consist of the absolute strengths and weaknesses of the SPU and/or the specific/all project(s). As a result, the assessment report contains a top 5 list of improvement areas and a preliminary plan of improvement suggestions for the organization as shown in Error! Reference source not found. [45].</td></tr>
<tr><td rowspan="2">Personal Software Process (PSP)</td><td>Personal Software Process (PSP) is a structured software development process that is intended to help software engineers understand and improve their performance, by using a "disciplined, data-driven procedure". The PSP was created by Watts Humphrey to apply the underlying principles of the Software Engineering Institute's (SEI) Capability Maturity Model (CMM) to the software development practices of a single developer.
The goal of the PSP is to help developers produce zero-defect, quality products on schedule. Low-defect and zero defect products have become the reality for some developers and TSP teams, such as the Motorola division in Florida that achieved zero defects in over 18 projects through implementing PSP techniques [79]. The PSP also uses statistical techniques, such as correlation, linear regression, and standard deviation, to translate data into useful information for improving estimating, planning and quality. These statistical formulas are calculated by the PSP tool.</td><td rowspan="2">In order to have PSP provides the quantitative standard and method to measure, compare and track the individual execution ability related to planning and method of work progress; PSP was designed based on the following 5 principles [58]:
Software developers should set up plans for their work based on their acquired data.
Software developers should use a well-defined and measurable process.
Software developers should take responsibility of the quality of the product.
Faster discovery and correction of defects of products ensures cost-saving.
Preventing defects is more effective than finding and correcting them afterwards.
In term of organizational level, using PSP schedule management tools allows clearer and more transparent time management and thus facilitates control on the overall schedule. In contrast, the term of individual level, using PSP schedule management tool provides understanding of the productivity against the time to complete the work and thus understanding of an individual working time pattern, proving a basis for removal of key factors causing inefficiency and error.</td></tr>
<tr><td>The goal of the PSP is to help developers produce zero-defect, quality products on schedule. Low-defect and zero defect products have become the reality for some developers and TSP teams, such as the Motorola division in Florida that achieved zero defects in over 18 projects through implementing PSP techniques [79]. The PSP also uses statistical techniques, such as correlation, linear regression, and standard deviation, to translate data into useful information for improving estimating, planning and quality. These statistical formulas are calculated by the PSP tool.
The PSP is a personal process that can be adapted to suit the needs of the individual developer. It is not specific to any programming or design methodology; therefore it can be used with different methodologies. PSP certification is offered by the SEI at Carnegie Mellon University.</td></tr>
</table>

Source: Research analysis compilation

2.1.2 Literature Review of Six Sigma in IT Processes, IT Services and IT Products

2.1.2.1 Introduction

Quality is key for any organization to survive, compete and move forward in today's increasingly competitive business environment. Quality is determined by the product users, clients or customers, not by society in general. The aim is not to eliminate mistakes or defect completely, but to minimize the occurrence of defects/mistakes a company can manage and handle. A suitable and flexible quality improvement initiative can help companies formalize a systematic well-rounded approach covering top management all the way to the operations level in handling day-to-day tasks. Six Sigma is one of the upcoming methodologies gaining popularity amongst IT and non-IT organizations in Malaysia [80].

This chapter aims to contribute to the awareness of implementing Six Sigma into various business areas of IT, not limiting to a single "sub-trade" of IT related businesses. This awareness will not only create clearer and un-biased views of Six Sigma in IT industries, but also create potential insights, guidelines and ideas for Six Sigma implementation in vast business areas of IT processes, IT services and IT products. Successful businesses inevitably place great emphasis on managing quality by focusing and directing its resources, money and time on a quality management methodology which drives operational excellence.

2.1.2.2 Six Sigma in IT Industry

There are many researchers who have conducted surveys and performed reviews on Six Sigma from different industrial perspective and background. Six Sigma applications in IT industries have drawn attentions from academic and non-academic groups over the past two decades. Academic reviewers focused on the theory, tools and techniques which Six Sigma integrates within the methodology to enhance the bottom-line results and win customer loyalty. Researchers had in-depth discussions on the methodology of Six Sigma DMAIC framework which is widely adopted and implemented. Researchers stressed in-depth analysis at each DMAIC phase to ensure root-causes are identified and analyzed, especially during the initial stage. Most academic reviews are supported with mini case studies and pilot surveys.

The non-academic group [81-83] (business expert, management expert, consultant etc.) has reported a series of abundant success stories of adopting Six Sigma as part of the QIM strategy to increase market share and maximize profit. The non-academic group emphases corporate quality which is measurable in terms of monetary, goodwill, effectiveness and efficiency (e.g. time reduction, product, manufacturing and environmental leadership, profit improvement and empowerment to achieve total customer satisfaction [47]). The achievements reviewed by the non-academic group are mostly business-related and are measured in dollars($).

In particularly, the reviews of Six Sigma in the IT industry are extremely diversified into the segment of IT processes, IT services and IT products; with IT processes dominating the population followed by IT services. However, the papers published on IT products have somehow been neglected by the academic authors but are set-off by the non-academic group. The non-academic group realizes the full potential and benefits of Six Sigma in IT production, design and development stages to enhance customer satisfaction, leading to improved long term profitability, increased product reliability and improved profit margins [84].

Table 2 outlines the collective outcomes of literature reviews and business related articles/magazines of different sub-areas of IT in Six Sigma implementation and adoption. The result clearly proved that there is a lack of general awareness of Six Sigma implementation and adoption in the IT industries of processes, services and products as a whole. There is an urgent need to create a general awareness among IT specialists regarding the feasibility adoption and implementation of Six Sigma into "all" business areas of IT industries (i.e. Processes, Services and Products) without skewing to single sub-area of IT.

Table 2 Collective Reviews Of Six Sigma In IT Industry

Research Group	IT Processes	IT Services	IT Products
Academic	[16, 21, 25, 36, 71, 85-105]	[14, 15, 24, 32, 37, 50, 102, 106-110]	[27, 57, 111, 112]
Non-Academic	[79, 81]	[32, 81, 113]	[81-83]

Source: Research analysis compilation

2.1.2.3 Six Sigma in IT Processes

Over the years, there is a rapid expansion of IT role from simply assisting and supporting business activities to managing and controlling IT related processes. IT roles are often used as a measurement indicator of respective company's maturity level [58]. The maturity of a IT process greatly depends on how accurately the process is defined, measured and controlled [58]. Highly matured processes means it has abundant well-defined and mature processes that are consistently applied to all the projects it carries out.

A survey conducted by Hairul et al., [64] has proven a strong linear relationship between high-quality IT development processes and high quality products. Therefore, it is important for IT companies to adopt QIM into the IT development cycle to maximize the resource output in the shortest possible time and gain better payback. The quality of the IT products are largely governed by the quality of the process used to build it [64]. It is important for the engineers, executives and managers understand the main purposes, advantages and disadvantages of each initiative and how the various improvement initiatives can potentially fit together in an integrated approach. In short, it is crucial to have a deep understanding of how an organization operates or should operate as a system. When business processes are in place, the route to quality and operational excellence is the next milestone.

IT development process is intangible and human-intensive [59]. Several development processes such as Waterfall, Prototyping, Spiral, and Iterative were developed to make obscure software process more visible and structured. Producing IT products and IT services is an expensive business. Making optimal use of available resources, both human and computer, is vital if IT development is to make economic sense [61]. Hence, Software Process Improvement (SPI) initiatives are therefore essential.

The common problem of "IT crisis" is about IT products and services taking too long to develop, cost too much, and does not work very well when eventually delivered [61]. Some argued that it is caused by undisciplined, chaotic and completely unpredictable software process, whereas some are blame on the rigidity and inflexibility of traditional QIM. Therefore, adopting the right QIM is an obvious and logical step in addressing the IT crisis and Six Sigma appears to be one of the most common QIM standards used by most IT-based companies. The evidence of success stories of Six Sigma application and implementation in IT Processes are summarized in Table 3:

Table 3 Success Stories of Six Sigma in IT Processes

No	Examples of Six Sigma in IT Processes
1	In order to explain "what" six sigma can achieve, Hong & Goh outlined a few impact-able examples as a result of non-stable IT process initiatives (i.e. legal responsibilities, mission-critical systems, complex system and IT outputs) which in return, the company was required to face an increase in customer dissatisfaction, fear of loss or damage of company's image, reputation, market share, drop in annual profit/return/revenue and other potential risks have yet to be disclosed [36]. The general framework and ability of Six Sigma has provided solutions to meet the mentioned challenges.
2	The "Six Sigma Project Management and Analysis system (SSPMA)" proposed by Lin at al., allows Six Sigma project management to work well and achieve continuous improvement [94]. The proposed SSPMA model puts the process of Six Sigma project management, data analysis and document management together to make sure that resources are effectively controlled and managed. Through this framework, project risks will be reduced, the project executors are able to implement the management and analysis in the same system which greatly improves work efficiency.
3	An Online Six Sigma Project Management platform has been reviewed by Zhedan et al., stating that the Software-Six-Sigma website [114] provides a standard process and analysis tools named Six Sigma Project Management Tools (SSPMT). SSPMT is ideal for Six Sigma project execution and also a platform for collaboration with other improvement approaches such as PSP/TPS and CMM/CMM-I [115]. The resulting SSPMT framework is beneficial in initiating and executing Six Sigma projects, facilitating data collection and data analyses by Six Sigma toolkits, and standardizing the Six Sigma project execution process so as to achieve the overall "project" and "business" goals.
4	The School of Computer and Advanced Technologies (SCAAT) of Phetchburi Rajabhat University had initiated a Six Sigma project applying the concept of Six Sigma DMAIC methodology into the school's strategy, mission and goals [116]. The success of the Six Sigma DMAIC project at SCAAT can be observed via the following IT functionalities: Authorize users access relevant info via centralized database; Allow user progress for each activity (view/edit); Send course evaluation via the interface; Allow communication with senior via messenger; On-line feedback in open-ended format; Meeting scheduling with lecturer/supervisor; Consolidate and generate reports for top management; Establish a platform for estate facilities complaint.
5	Li & Qi introduced a new approach to measure requirement changes based on Six Sigma methodology [117]. The framework of Goal-Question-Metric (GQM) and the Six Sigma DMAIC process were combined and applied in a more operable management of software projects more operable. The problems found or identified in the earlier stages of GQM were taken into account and actions should be taken to eliminate these problems in the next project. This review has proven that Six Sigma approach is more feasible for IT project management and continuous quality improvement.
6	As cited by Edgeman et al., [50]: "……a general lack of awareness as to how to engage in meaningful correction from inefficiencies, inconsistent and undocumented processes." In recognizing these barriers to organizational improvement, the chief technology officer (CTO) has assigned one "Six Sigma" team focusing on DFSS-DMAIC responsible for integration across the various areas and improvement perspectives. The self-assessment by the Six Sigma approach derived solutions and responsibilities for implementation.
7	MiniDMAIC approach coupled with Casual Analysis and Resolution (CAR) in IT development projects [60] is a strategy that simplifies the DMAIC model in order to address problems caused. The goal of used a large number of different tools and methodologies for addressing problems. The MiniDMAIC approach helps organizations to achieve higher maturity levels, increase customer's satisfaction and reduce process variation in their search for operation excellence.
8	Li & Qi conducted a research based on Six Sigma DMAIC methodology to improve the efficiency of IT help-desk service through an eHelp-desk system [110]. Li & Qi adopted the Six Sigma concept depicting a "Triangle Relationship" that integrates three attributes of customer quality, science manners and team work. The case company indeed gained a substantial financial benefit and also the dramatic improvement in service quality. Users may check their requested progress through the eHelp-desk system. The financial benefits resulting from this new system are estimated to be NTD1,942,560 per year and the latent financial achievement will be

No	Examples of Six Sigma in IT Processes
	NTD26,856 per month; the repair time for each customer request will be reduced from 131 minutes to 71 minutes.
9	Seagate has a dedicated team for contracts maintenance which applies Six Sigma into the Contract Improvement Process [82]. The team analyzed what was needed and defined what maintenance level was wanted and saved $1.5 million from the process improvement. Seagate has adopted Six Sigma as an official approach to all its' contracts (hardware, software and outsourced services).

Source: Research analysis compilation

2.1.2.4 Six Sigma in IT Services

The popularity of Six Sigma in service organizations is growing every day, and even many manufacturing companies today are focusing their Six Sigma efforts on service-oriented processes where they achieve maximum return on investment [15]. The strength of Six Sigma lies in its' well-planned framework and its' focus on process improvement. In supporting the service organization, IT executives and managers will be challenged to transform their organization from delivering technology to providing service and ultimately becoming a business partner within the organization [65].

Six Sigma has been implemented successfully in a broad range of services and services processes; which does consume a major chunk of a company's operating margin [15]. Since then, Six Sigma has inspired the public for the past few decades and it has now extended its application from manufacturing to service industries such as Ritz-Carlton Hotel Company [37]; GE Capital [37]; GE Functions [37]; American Express [37]; IBM [37]; CitiBank [14, 29, 37] ; J P Morgan [14]; American Express [14]; Lloyds TSB [14]; Egg [14]; Zurich Financial Service [14]; British Telecommunication [14] etc. The evidence of success stories of Six Sigma application and implementation in IT Services are summarized in Table 4:

Table 4 Success Stories of Six Sigma in IT Services

No	Examples of Six Sigma in IT Services
1	Wire-transfer operation at international private banking [14, 118]. The reported outcomes are: reduce delayed for wire-transfer, improve customer satisfaction, retain valued customer, improve company reputation, transfer cycle time improve by 46%, reduce cost-per-payment by 50%, annual saving of $1 million.
2	Loan processing platform using "Clientele" at Lending mortgage banking firms [118]. The reported outcomes are: increased customer satisfaction by 350%, improved response time by 350%, reduced abandoned customer call from 12% to 4%, reduced process redundancies by 66%, improved loan retention by 20%, elimination of $21 million in risk exposure, annual saving of $5.5 million, additional revenue of $1 million.
3	Price war in equipment setup cost of optical network versus wire-line network for different cabling at telecommunication company [118]. The reported outcomes are: total spending on equipment fell by 15% in 2001 and 20% in 2002, operational focus, financial discipline, opportunist growth.
4	Developed a database to track life-cycle-order for sales-to-cash interval at a private branch exchange dealer/distributor [118]. The reported outcomes are: reduced interval time by 7.5 days (initially is 4 months), annual saving of $420,000, increase accuracy and timeliness of customer billing, improve forecasting accuracy, reduce internal cost, improve collection process, reduce excessive delays.
5	Implement a new call strategy for business market collection at telecommunication provider [118]. The reported outcomes are: reduction of defects in collection processes, collection of 60-day past dues improved by 18%, increased revenue by $2.4 million.
6	Implement call strategy for credit card application at private banking at Citibank group [96]. The reported outcomes are: reduced internal callback by 80%, reduced external callback by 85%, reduce credit card processing cycle time by 50%.
7	Application software assistance to track order-to-delivery and credit decision cycle at Global equipment finance at Citibank group [96]. The cycle time from placing order to service delivery and credit decision cycle is reduced by 67% (from 3 days to 1 day).
8	Financial software assistance for statement processing at Copeland companies at Citibank group [96] reduced from 28 days to 15 days.
9	Process handling for customer-facing services at Global Investment Banking at J P Morgan Chase [119]. The reported outcomes are: reduce flaws in account opening, payment handling and cheque-book ordering; increase customer satisfaction and improve efficiency and cycle time by over 30%.
10	Credit card renewal services at bank [109] has significantly reduced and the number of returned renewal credit cards and credit card defect rate is reduce from 13,500 DPMO to 6,000 DPMO.
11	Application software assistance in handling radiology throughput [120]. The reported outcomes are: increase radiology throughput by 33%, decrease cost-per-radiology procedure by 21.5%, savings in excess of $1.2 million.
12	Operation handling of patient transfer from the ER to an inpatient hospital bed has improved patient safety significantly and added

No	Examples of Six Sigma in IT Services
	$600,000 in annual profit [121].
13	Financial software assistance in handling errors of account receivables within an accounting department results in improved cash flow and savings over $350,000 annually [122].
14	Operational improvement for customer-service related activities within the contract department (utility services, excavation, cable-laying, re-instatement contract) at a Utility Company where customer complaints are reduced from 109 to 55 during year 2000-2001 [123].

Source: Research analysis compilation

2.1.2.5 Six Sigma in IT Products

Product can appear in various forms ranging from a good, an idea, a method, information, an object, or service that is the end result of a process and serves as a need or want satisfier [124]. According to Kotler and Armstrong [125]; "In marketing, a product is anything that can be offered to a market that might satisfy a want or need", "In retailing, products are called merchandise", "In manufacturing, products are purchased as raw materials and sold as finished goods", "In insurance, the policies are considered products offered for sale by the insurance company that created the contract" and "In investment institutions, customized investment plans are the end products companies offer to their investors". Therefore, a "product" must NOT always be a "machine" related item as it greatly depends on respective business nature.

In IT project management, hardware and software are the two main components of IT product deliverables. The term computer hardware is best described as all the physical parts of your computer and related devices, or the parts you can feel and touch. It includes not only the computer but also all the internal and external components that make up the computer such as cables, connectors, power supply units, and peripheral devices such as the keyboard, mouse, audio speakers, printers, motherboards, hard drives, RAM, monitors etc. [126].

Software consists of carefully-organized instructions and codes written by programmers in any of the various special computer languages [30]. Software is created with programming languages and related utilities, which may come in several forms: single programs like script interpreters, packages containing a compiler, linker, and other tools; and large suites (often called Integrated Development Environments) that include editors, debuggers, and other tools for multiple languages [126]. Software is often broken into two major categories: system software and application software [127]. System software is responsible for controlling, integrating, and managing the individual hardware components of a computer system so that other software and the users of the system sees it as a functional unit without having to be concerned with the low-level details [126]. The examples of system software are: transferring data from memory to disk, or rendering text onto a display.

Application software handles multitudes of common and specialized tasks a user wants to perform, such as accounting, communicating, data processing and word processing. Application software may consist of a single program, such as an image viewer; a small collection of programs (often called a software package) that work closely together to accomplish a task, such as a spreadsheet or text processing system; a larger collection (often called a software suite) of related but independent programs and packages that have a common user interface or shared data format (such as Microsoft Office), which consists of closely integrated word processor, spreadsheet, database, etc.; or a software system. In short, an IT product may refer to MS-Office, VoIP Telephony system, an executable file (BAT, COM, DLL, EXE, CSH, VBS, WS etc.), ticketing system, accounting system, processor (Intel, AMD etc.), memory chips, customized system, off-the-shelf software, helpdesk application systems, CRM, e-Commerce website and lots more. The evidence of success stories of Six Sigma application and implementation in IT Products are summarized in Table 5:

Table 5 Success Stories of Six Sigma in IT Products

No	Examples of Six Sigma in IT Products
1	Textron used the Six Sigma DMAIC process and the Voice of the Customer (VOC) tool, to tackle data-center sprawl [81]. Textron managed to downsize its existing 80 data centers by 50% by adopting Six Sigma DMAIC process. Data from various sites are carefully analyzed and consolidated into a single master database to be shared among all data centers around the world. The systematic step-by-step Six Sigma approach has significantly contributed to resource and financial savings.
2	J P Morgan Chase Financial Services formed a Six Sigma team to analyze and investigate the costs accrued by customer service representatives [81]. The adoption of Six Sigma DMAIC into the voice-response systems has finally recognized the need to incorporate the intelligent voice recognition system into the voice-response system. This enables customers to find their own answer easily for routing questions, which in turn allowed service representatives to redirect their efforts into selling additional products.
3	Mark A. Brewer, senior vice president and CIO of computer manufacturer Seagate Technology revealed that Six Sigma methods work well in reducing errors across IT operations [82]. Seagate's IT department booked direct savings from Six Sigma analyses of $3.7 million during the fiscal year 2002. Since the institutionalizing Six Sigma two years ago, the IT department has saved $4.5 million overall. The company as a whole reported saving more than $956 million since adopting Six Sigma methodology five years ago [82].
4	A project of Computer Manufacturer Seagate Technology was reported with high amount of leftover scrap from a critical manufacturing hard-disk process. A black belt from IT was assigned to tackle the problem and discovered that the data files were taking too long to transfer to another system for analysis. By applying Six Sigma methods to this problem, the root cause was found and appropriate tuning was done to the network and file server (lowering process time from 19 minutes to 5 minutes resulted in millions of saving for the company [82].
5	The IT department of Raytheon Aircraft has used Six Sigma to improve claims processing and save the company $13 million [82]. The program codes or algorithms are analyzed and revised to reflect the needs of the organization. These repeatable activities promote continuous improvement and competitive advantage to the end products which has direct impact to the organizations' ROI.
6	MIMOS is always committed to develop, produce and release high quality software to market and they have successfully established and implemented a Test Defect Prediction (TDP) model using the DFSS (Design for Six Sigma) methodology [57]. This prediction or estimation of defects for particular software during testing phase is very crucial in enhancing the testing process in system development life cycle (SDLC). By predicting the total number of defects at the start of testing, it allows for wider test coverage to be put in place. As more defects are contained within testing phase, it helps in improving quality of software and hardware product being delivered to end user. At the same time, it demonstrates the stability of development effort prior to releasing a software and hardware product.
7	Seagate faced the problems of server bandwidth with server resides in the United States, and the response time in Asia is very poor. Seagate's Six Sigma team used a DMAIC approach to analyze several servers around the world and measured the servers' respond times [82]. The team found variability in servers' response time that had nothing to do with bandwidth. The DMAIC improvement approach into server tune-up has brought the response time way down [82]. Seagate didn't buy bandwidth or software; it didn't cost Seagate anything. Seagate found the root problem using DMAIC approach and solved the issue without costing much to Seagate.
8	Antony & Coronado shared a GE case study of Lightspeed Diagnostic Scanner using DFSS Methodology in project risk management [84]. At the end of 1995, customers demand better and faster scanners and GE faced fierce competition from Toshiba and Siemens. GE adopted Six Sigma methodology (DFSS) focusing on solving leaks in the scanner's vacuum tubes. A sum of $50 million was invested involving 200 people in 3 years running 200 separate Six Sigma projects related to the scanners' vacuum tubes. The implementation of Six Sigma solved the leaking problem in vacuum tubes; reduced the pre-shipment scrap by 40% which increase efficiency and accuracy in data processing which further reduce scanning time.
9	The Commonwealth Health Corporation (CHC) partnership with GE adopting Six Sigma DMAIC into its' radiology equipment embracing Six Sigma tools and techniques finding ways to leverage the data which drives human behavior [128]. The pool of human behaviors is accumulated and analyzed using pre-defined logics to better analyzed disease's patterns and diagnoses. CHC has realized improvements in excess of $1.2 millions, improved radiology throughput by 33% and decreased cost per radiology procedure by 21.5%.

Source: Research analysis compilation

2.1.2.6 Summary

In the midst of promoting Six Sigma project management, there were many problems raised and one of the critical issues is to deal with low-information level of data. In the context of IT, the business operation activities are heavily dependent on data (raw or processed) and the end result will be stored or resided somewhere (normally in a database) for future use. Six Sigma methodology has evolved into a statistical oriented approach to IT processes, IT products and IT services quality improvement. DMAIC, DFSS or Six Sigma Roadmap Case Study approach is the solution to design products, processes and services in a cost-effective and simple manner, to meet the needs and expectation of all customers. It utilizes the powerful and useful statistical tools to predict and improve quality before building prototypes.

Many companies are incorporating Six Sigma into IT product life cycles where Six Sigma methodologies of DMAIC or DFSS are used as a basic tool for IT projects. More and more IT project managers are leading the trend of black and green belts as part of their career achievement and advancement. Quality lives in the hands of responsible people who are empathetic of the advantages of Six Sigma. Six Sigma invigorated quality by transforming bottom lines positively, company after company. Some of the cynical views against Six Sigma appear to have been triggered by companies that have looked at quality in theory, and not based on results. Any quality system without data-driven results is “quality on papers”. It is entirely up to the Quality Assurance (QA) manager manipulating the level of conformance according to “one’s” desire.

Six Sigma whose tools were created and perfected over nearly a century, has electrified the business environment and customers, which are the ultimate benefactors of its results beyond the manufacturing industry. This clearly proves that Six Sigma indeed has great potential in the area of IT processes, IT services and IT products as a whole; and no longer dominates in single business area or sub-trade of IT industry. Fundamentally, IT organizations and IT specialists (especially in the region of South-East Asia) should see Six Sigma as a structured knowledge-acquisition and problem-solving approach assisting in honing the missions of mercy which intends to bring quality in IT Processes, IT Services and IT Products more and more, now and the future.

2.1.3 Which Methodology to choose?

2.1.3.1 A Roadmap to Quality Improvement Methodology (QIM) Selection

Currently, there are various approaches to implementing quality improvements. Therefore, successful businesses inevitably place great emphasis on managing quality. The popularity of a company’s products or service will be enhanced only if a proper quality system is in place. Therefore, a company needs to focus and direct its resources, money and time on a quality management methodology which drives operational excellence. Trends that are supposed to promote powerful quality techniques often become totally counterproductive to quality-focused improvement efforts. Hence, the management team must view quality improvements as a continuous process and as part of the organizational level activity.

Industrial, manufacturing and service organizations are interested in improving their products, services and processes by decreasing variations because the competitive and stressed environment leaves little room for error. Variation is the enemy of quality, which is defined and evaluated by customers. The project team must deliver and develop products, process and services at the ideal targets (or acceptable level of variation) demanded by the customers. The traditional evaluation of quality is based on average measures of the process, product and service; and their deviation from the target value. However, customers judge the quality of process, product and service not only based on the average, but also by the variance in each transaction with the process, product and service or use of the product [11].

Hence, consideration of a roadmap towards world-class quality is crucial. However, one needs to be cautious in adopting existing roadmaps without matching the company culture and objectives. Companies should understand that any simple roadmap would never work without a company culture characterized by the core business principles and visions of the organization [29, 41].

2.1.3.2 Mapping Quality Improvement Methodologies

There are many researchers who have conducted surveys and performed reviews on different QIM trying to determine which method works and fits a company best. Generally, the approaches to mapping QIM can be categorized into the following:

- road mapping by detailed description and by illustration with examples or case studies on QIM [29, 34, 41, 44, 58, 68, 129-136]
- road mapping by comparison of two [34, 41, 58, 129, 132] or more [40, 41, 46] QIM

Most researchers embark on their QIM road mapping by a detailed description and with illustration and supportive evidences from conducted surveys. This approach of road mapping no doubt has outlined a comprehensive understanding and is capable of justifying with a high level of confidence the adoption of a relevant methodology. Unfortunately it is solely based on a single QIM where differentiating and distinguishing the suggested roadmap against other QIMs may be lacking. In addition, this approach may be seen as biased as the suggested QIM is proven to work well only in that specified business environment in which it was claimed to have resulted in much benefit and returns from this method of road mapping. Furthermore, this approach has overlooked the time concern when applying the suggested QIM. Whenever an organization had adopted a QIM, much effort and time is required in keeping, managing and monitoring routine quality operations. Can one assure that the adopted QIM is still the “best fit” for an organization after a period of time when the organization has reached a higher level of maturity? Organizations may find the adopted quality improvement no longer fulfills and satisfies its' business objectives and this leads the organization to opt or seek for a better QIM which provide a comprehensive top-down approach allowing the organization to strive for competency and competitiveness among its competitors. In short, an organization may change with time and applying such a narrow approach in selecting a certain methodology may prove to be a mistake in the long run.

A simple roadmap of single process thinking and mapping containing ISO, Lean and Six Sigma was discussed by Bendell [34] which serves as a quick-start guidance to companies on mapping of business process improvement. Bendell has taken it a step further by summarizing the theory-based roadmap into simple picture representations showing the mapping of QIM of ISO, Lean and Six Sigma. However, the proposed graphical roadmap is limited to discussion of three QIM only; this approach limits other QIMs comparison and explorer such as ITIL, CMM, SPICE, TQM etc. which may offer consistent, reliable and quality products, operations and services to their customers. On the other hand, Nave had adopted a different approach in selecting different improvement methodologies in over-coming business obstacles [46].

2.1.3.3 A Proposal to Road Mapping

The author proposed a hierarchy model which discussed the cause and effect relationship of QIM, which focused on the fundamental primary and secondary effects of the philosophy of each improvement methodology:

- Firstly, the author identified the primary theory and the core emphasis (i.e. short phrase which best describes the improvement methodology) [34].
- Secondly, the author established the relationship between the primary theory and the primary focus of the tools and methodology through the if/then statement [46].
- Thirdly, the author identified the secondary effects by using the if/theory and primary effects/results type statement.

Once the values of a specific improvement methodology are identified, the method of selection will become clearer and easier. Even though this way of road mapping is also another example of theory-based road mapping, it went a step further by considering how the primary and secondary effects of different QIM affect the selection process. However, the reader is still required to browse through all the necessary details of all the QIM (in this case are TOC, Six Sigma and Lean) before making a decision on the selection process.

One commonality among the discussed road mappings is that most of the empirical research is focused on one or a few QIM. It would be either a single theory-based methodology, integration of two or more theory-based methodologies or comparison of two or more theory-base methodologies. Most of the time, reviews are done in accordance to a category of QIM, e.g. industry sectors (manufacturing versus non-manufacturing; software improvement initiative etc.);

which create an unnecessary restriction and limitation of adopting another potential QIM which may suite an organization better and provide the best fit for a company.

2.1.3.4 Quality Improvement Methodology Roadmap

The **first level** of primary mapping is dealing with the core emphasis of the primary theory of different QIM. These primary theories and the core emphases of the respective QIM are represented visually in a picture road-mapping representation as shown in Figure 1. This picture representation gives the reader a better overview of each QIM. When the reader is interested on a particular selected QIM, they can proceed to the next level of road mapping.

This study proposed to categorize the first level of the QIM selection mapping into IT-related and non-IT related businesses; with the reason being BOOTSTRAP, SPICE, CMM/CMM-I, ISO, ITIL, PSP and Six Sigma are software process improvement initiatives which assist organizations to achieve more predictable results by incorporating proven standards, procedures, guidelines and a framework for an organization's IT-related business processes. On the other hand for non-IT related businesses; the commonly reviewed and discussed methodologies are TQM, TOC, Lean, Six Sigma, Lean-Sigma, ISO etc.

From the review of different papers, the primary theory and the core emphases of the respective program or methodology are:

- **Non-IT related businesses:** **"***TQM is customer satisfaction***"**, **"***TOC is constraint reduction***"**, **"***Lean is waste reduction***"**, **"***Six Sigma is variation reduction***"**, **"***Lean-Sigma is corporate sustainability***"**, **"***ISO is getting basic right***"**
- **IT-related businesses:** **"***BOOTSTRAP is software process assessment***"**, **"***SPICE is evidence focus***"**, **"***CMM/CMM-I is maturity focus***"**, **"***ISO is quality assurance***"**, **"***ITIL is ITSM library***"**, **"***PSP is discipline enforcement***"** and **"***Six Sigma is bugs reduction***".**

The **second level** of road mapping focused on fundamental primary and secondary effects of the philosophy of each improvement methodology. The suggested road mapping involves identifying the relationship which indicates how the primary theory benefits itself in a tangible result (primary result) and secondary effects with the aid of an "if/then" statement and "if/theory and primary results/effects" statement. The if/then statement is the most basic control flow statement which is well-understood and hence is a good approach in this deductive reasoning selection process of QIM. The second level is expanded to support identification and evaluation of the values of a specific improvement methodology by comparing those values with the values of the organization. This approach can make the QIM selection process clearer and easier.

Source: Research analysis compilation

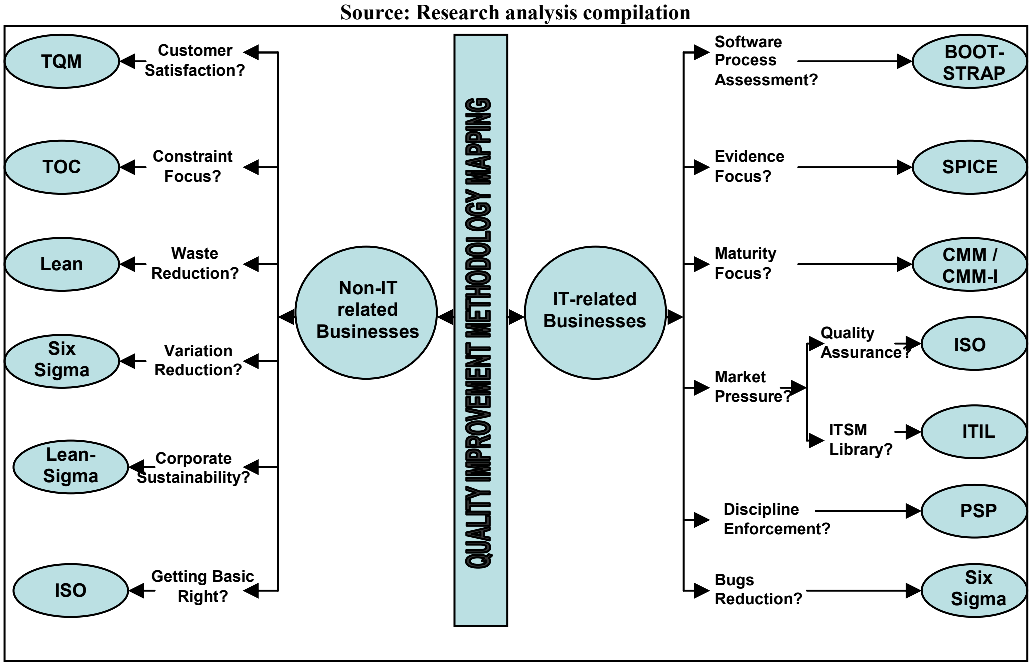


Figure 1 Quality Improvement Methodology Mapping (First Level) [137]

The following is the proposed roadmap which identifies the fundamental relationship of the primary and secondary effects of each improvement methodology with the aid of an "if/then" statement. These statements are developed through a combination of common descriptions found in the literature and the implied focus of each methodology:

- **TQM** : "*If* focus on customer satisfaction and continuous improvement *then* it results in lower cost, better fostering of team work, better fulfilling Voice of Customer (VOC), improved competitiveness and effectiveness [49]"
- **TOC** : "*If* focus on constraints and increased throughput *then* it results in less inventory and a different accounting system" [46]
- **Lean** : "*If* focus on waste and flow time *then* it results in less variation, uniform output and less inventory" [46]
- **Six Sigma** (non-IT related) : "*If* focus on reducing variation and achieving uniform process *then* it results in less waste, less throughput time and less inventory" [46]
- **Lean-Sigma** : "*If* focus on corporate sustainability [77] and team work from both shop floor and Six Sigma team *then* it results in better problems tackling, better employee morale and better inspiration of culture change [76]"
- **BOOTSTRAP** : "*If* focus on process assessment and continuous fine-tuning [138] *then* it results in better assessment report and preliminary plan for improvement suggestions [45]"
- **SPICE** : "If focus on software lifecycle processes and process capability level *then* it results in better software processes assessment, better gap management between current capability and the level required by the organization" [139]
- **CMM/CMM-I** : "If focus on achieving maturity and framework guidance from one level to the next *then* it results in urging organizations to think of continuous improvement for customer satisfaction" [140]
- **ISO** : "*If* focus on established guidelines and improve organizational cycle time *then* it results in more efficient and effective operation, increased customer satisfaction and retention; improved employee motivation, awareness and morale" [30]

- **ITIL** : "*If* focus on IT best-practices and quality is everyone's responsibility *then* it results in better demonstration of company's ROI [65], higher productivity from business and IT staffs"
- **PSP** : "*If* focus on software engineers and commitment enforcement *then* it results in better estimation skills, better planning skills, keep commitments one's made, better managing the quality of their projects and reduce defects" [103]
- **Six Sigma** (IT-related): "*If* focus on reducing bugs and tackling problems that cause the defects *then* it results in less bugs, better simplification on design, better customer satisfaction, better quality software, process and product" [18]

Last but not least, the selection process of improvement methodology is dependent on the culture of your organization [33]. If many popular QIM appear to end up with theory-based and comparison methods of road mapping, it is important to identify and evaluate the values of a specific improvement methodology by comparing those values with the values of the organization which makes the method of selection clearer and easier:

- If an organization *values the change of corporate cultures from a passive and defensive culture to a pro-active and open culture*, then **TQM** is the right approach for strategic view of quality.
- If an organization *values a system approach where total participation is not desired and if it values the separation between workers and management*, then **TOC** will be the good way to start.
- If an organization *values visual change and right now time*, then **Lean** thinking might be the way to go.
- If an organization *values analytical studies and the relationship of data, charts and analysis*, then **Six Sigma** is a perfect program (IT-related and non-IT related).
- If an organization *values ongoing business improvement and sustainability*, then **Lean-Sigma** will be the next upcoming trend.
- If an organization *values the organization-wide improvement actions*, then **BOOTSTRAP** will be a good assessment tool.
- If an organization *values the evidence determination of an organization's capability*, then **SPICE** is the upcoming standard.
- If an organization *values maturity process as part of the learning curve*, then **CMM/CMM-I** is the only model.
- If an organization *values conformance of organization's wish-lists (QM)*, then **ISO** will be the best to start with.
- If an organization *values aligning IT services based on business needs*, then **ITIL** has the baseline boundary in the library.
- If an organization *values the soft and hard skills of the software engineer*, then **PSP** will reflect immediate outcome.

The mapping directions shown in Figure 1 are not, of course, mutually exclusive. The figure provides a basic and holistic mapping of QIM which helps IT and non-IT related organizations in finding the appropriate methodology in accordance with respective business needs and business nature.

It is also advised to move forward combining the picture representation of selection to QIM without neglecting the importance of detailed theory-text description using the if/then statement. This mutually complementary approach enables the designing of a flexible roadmap which makes future expansion hassle-free. This study has not addressed all possible types of QIM. Benchmarking, Balanced Scorecard, COBIT etc. would be the next target of future research since the proposed roadmap is flexible in expanding to include more QIM.

2.2 Research Findings – Quality Improvement Methodologies on SMEs in Malaysia IT Industry

2.2.1 Introduction

The role and associated responsibilities of the IT department has become a vital and integral part of every industry. IT departments play an important role in the day-to-day business operation from principal means of cross departmental communication connection to information sharing and integration via system software, hardware, networking & communication infrastructure, support, business intelligence and reporting. Over the years, IT departments oversee a company's business routines and transactions; providing a simple, effective, efficient and inexpensive means of communication in the business world. The role of the IT department in the organization is to deal with all the issues regarding information technology. Today, the advancements in technology have placed IT departments in an important role to provide technological support to the whole organization wherever needed.

An online questionnaire was conducted with a group of SMEs in the Malaysian IT industry. The online survey used in this study consisted of two parts: (1) The background of the company and (2) The practical views of QIM's "norm" and "patterns" in Malaysia's SMEs IT industry. This survey was carried out in the first quarter of 2012 and the data collection process lasted for three months and the results were analysed, tabulated and summarized in the following sections.

This research finding presents an overall view of QIM evolution in the past, current and future adoption/implementation in Malaysia's SMEs IT industry. It also illustrates a set of commonly used tools and techniques within the surveyed companies for continuous improvement in process performance. A pool of resistance factors and key success factors for the implementation of QIM in Malaysia's IT SMEs are also addressed and discussed. Besides, "the objectives of QIM adoption", "common measurement metrics in the IT industry", "primary and secondary measurement benefits", "project authority", "pre-QIM training" and "non-existence of QA department" are also presented in this report. This research finding offers qualitative as well as quantitative practical views of the challenge faced by Malaysian SMEs in IT industry in adopting QIMs and providing customers with quality assurance and quality control on their products/services via adopting/implementing a single or hybrid set of quality improvement initiatives.

2.2.2 Research Methodology

The authors conducted the study in several stages. Firstly, an extensive literature review of various adopted QIMs in the IT industry were carried out as a means of understanding how different QIMs fit into the project life cycle (PLC) of the IT industry. The set of QIMs included in the survey derived from the proposed "Roadmap to QIM (Figure 1)" in Section 2.1.3 (i.e. QIMs for IT-related businesses). In addition, the QIMs of Business Process Reengineering (BPR) [141], Balanced Scorecard [142, 143] and Lean-Sigma [48, 144, 145] were included in the survey as a result of continuous effort in literature reviews. Next, the literature review was extended to include the "norm" and "patterns" of QIMs in Malaysia's SMEs IT industry in the context of IT project management as discussed in the introduction at Section 2.2. The literature outcomes from these stages were used as the basis to devise a questionnaire for this study.

Each respondent was instructed to choose a choice of four predetermined answers, ranging from '*Most Important*' to '*Least Important*' and/or from *'Very often'* to *'Never'*. Each of these answers had a defined weightage level *(1),* where an 'Influence Level score' and/or 'Level of Importance' for each of the defined factor can be attributed through equation (1). Where, S_f represented the total influence level score for the factor (*f*) under consideration, calculated using *I*(x), which represents the influence level weightage and N(x), which represents number of respondents for the influence level under consideration.

$$S_f = \sum_{x=0}^{x=3}([I(x) \text{ x } N(x)]^2) \quad (1)$$

Similar studies from Brietzke [146] and Nasir [95], used influence level weightage as a means of providing a comparative basis across the pre-identified resistance factors. A higher score (*S*) therefore would imply that the resistance factor had a more significant effect on the implementation of Quality Management in the IT sector. In order to isolate the method that displays the most significant difficulty in implementation among the five (i.e. level of influence), the following formula (2) was used:

$$S_{T,qm} = (\sum_{f=1}^{f=30} S_{f,qm})/N_{qm} \quad (2)$$

$S_{T,qm}$ calculates the total influence level score (Table 6) for the particular quality methodology per respondent, *qm,* where $S_{f,qm}$ represents the individual score for each resistance factor from 0-30 for the particular methodology, and N_{qm} is the number of respondents who have *previously used* or *are currently using* the methodology. Here once again, the assumption states that the higher the $S_{T,qm}$, the higher the barriers experienced during implementation.

Table 6 Influence Level Weightage

Questionnaire Answer Choice	Influence Level Weightage (x)
Not a Factor	0
May be a factor	1
Significant Factor	2
Very Significant Factor	3

Source: Research analysis compilation

2.2.3 Background and Demographic Information

The targeted demographic information for this study is: (1) Company Background; (2) Respondent Background. In the section of "Company Background", the survey was to find out the business nature and number of full-time employees of respective surveyed company. A number of questions are defined specifically to the expertise levels and designations of the participants to judge their views and suggestions.

The approach of stratified sampling method was adopted where the survey population only embraces the MSC status companies (i.e. Listing of MSC status companies obtained from MDeC official website) of different business areas covering software houses, hardware manufacturers and retailers, software distributors, IT consulting services and others. This allowed the study focuses on relevant and important IT companies and ignores irrelevant one.

A total of 100 online survey invitations were sent to IT companies of different business areas. The response rate from these invited companies was 37 percent (37 companies). A total of 81% (34 companies) of the surveyed companies are from the category of Medium-Enterprise of SMEs with 20-50 full time employees [18], the remaining three (i.e. 8%) companies are from the Small-Enterprise category with 5-19 full time employees. From the sample size of 37 companies, 62% of the surveyed companies have more than 20 years of exposure and experience in their respective businesses; where 24% recorded less than 10 years of IT business operation experience and a minority of 14% with 10-20 years' experience in the business.

The majority of the respondents were Project Managers (27%), Software Engineers/Developers (24%), System/Business Analysts (22%), IT Consultants (8%) etc.; with respective working experience of 10-15 years for Project Manager, 2-8 years for Software Engineer/Developer, 5-8 years for System/Business Analyst and 5-10 years for IT Consultant. The consolidated demographic findings from this study represents a strong sample of experienced IT personnel from a variety of IT businesses where the views and suggestions from this group of first-line management level, e.g. Project Managers, System/Business Analyst, Software Engineer/Developer and IT Consultants (i.e. total of 81% from total sample size) can be categorized as representative views from the IT project team.

2.2.4 Analysis of the Survey Data

2.2.4.1 The Evolution of Quality Improvement Methodology in Malaysia's IT Industry: The Past, Current and Future

All the respondents attempted the adopted QIM questions for the past, current and future. The summary of QIM adoption and implementation showed that more than 97% of surveyed companies adopted a QIM as a means of continuous improvement for their business. However in the present situation, all companies adopted a "single" QIM with a few companies (i.e. 10 companies or 27%) adopting more than one QIMs, i.e. integrating more than one QIMs to cope with increasing customers' needs and demand. The feedback for future quality improvement initiatives is encouraging too, knowing which QIM to adopt in the future to align with future organizational directives.

The analysis of the survey revealed that the evolution of different QIMs adoption in Malaysia IT industry has resulted in ISO being the most commonly adopted QIM in the past followed by CMM/CMM-I, Balanced Scorecard, ITIL and Six Sigma. To-date, ITIL followed by Six Sigma appears to be the major QIMs being implemented in most of the IT companies; with ISO facing an obvious decreasing popularity among IT companies. Six Sigma and Lean-Sigma have appeared to be the future rising stars gaining attention amongst IT companies as a means of continuous quality improvement compared with ITIL and ISO for day-to-day quality management. Table 7, Figure 2 and Figure 3 outline the adoption and evolution of QIMs of Malaysia's IT companies in the past, current and in the future trend.

Table 7 The QIM for the Past, Current and Future [147]

QIM	Past QIM (36 Responses)	Current QIM (47 Responses)	Future QIM (35 Responses)
CMM/CMM-I	4	3	2
ISO	7	5	2
BPR	3	4	2
SPICE	3	3	1
Balance Scorecard	4	3	1
BOOTSTRAP	2	2	2
ITIL	4	12	5
PSP	3	3	2
Lean-Sigma	2	3	8
Six Sigma	4	9	10
Total	**36**	**47**	**35**

Source: Research analysis compilation

Source: Research analysis compilation

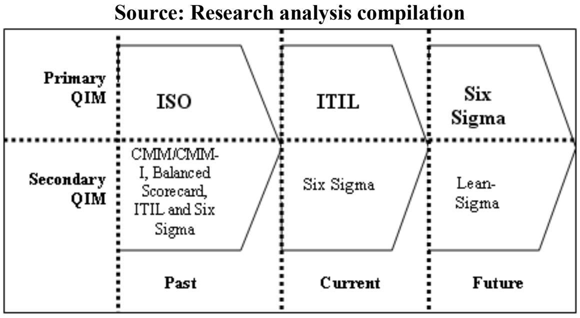


Figure 2 The Evolution of QIMs in Malaysia's IT Industry [13, 80, 147]

Source: Research analysis compilation

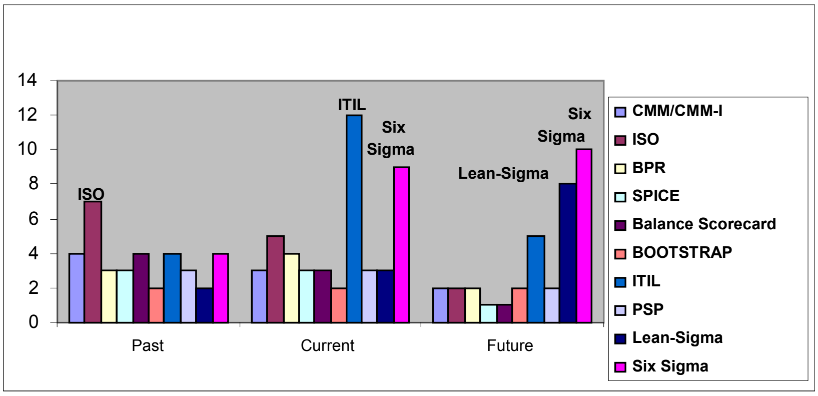


Figure 3 The Adoption of QIMs in Malaysia's IT Industry [13, 80]

All surveyed companies adopted one or more QIM currently; with a majority of the project teams (i.e. 83%) being satisfied with the performance of the currently adopted QIM. This is supported by a big segment of respondents (92%) revealed their support of QIM as a necessity for their organization; whereas only a small sample of 8% does not encourage QIM implementation and sees QIM as redundant and unnecessary. This concluded that an integration of QIMs is necessary to put project processes in place to ensure the organization can maximize project outcomes with constraints and limited project resources.

2.2.4.2 The Objectives of QIM Adoption

In view of gathering and compiling the listing objectives of QIM adoption in the context of project management in the IT industry, the author uses the collective views from IT Project Management reference books from Schwalbe, Kerzner, Hoffman, Marchewka and Meredith & Mantel [30, 31, 148-150] as basis to gather main objectives of QIM implementation from surveyed companies. The top five main objectives of QIM implementation in Malaysia IT industry are (Table 8):

- *Getting things right*. A project is a collection of integrated tasks/activities throughout the project life cycle (PLC) involving team members from different backgrounds and culture. Compliance to standards and regulations is one of the biggest challenges and in most cases the project team has difficulty conforming to the requirement. Hence, it is necessary to develop a sense of collaboration and focus on project quality related issues where all team members can foster and share common best practices to ensure standardization and compliance becomes less of a challenge.
- *Manage customer expectation*. According to Schwalbe [30], there is a positive relationship between product quality and customer satisfaction. Customer satisfaction needs to be prioritized by encouraging customer feedback. The overall quality of IT project's deliverables becomes the key focus of project sign-off milestone which traverses through the PLC from product development to product delivery and on to customer satisfaction. The customer will experience the best of the end-product when all team members focus their energy on quality with a QIM in place. This will ensure all project related mistakes and risks are reduced, which in turn saves project time and money. Savvy customers in competitive economic times do not

want to waste their time on companies who can't deliver on promises.

- *Corporate sustainability*. Any IT organization invested in quality control gains a competitive advantage [13]. Customers value quality in products and services they received and have the tendency to foster loyalty with companies that emphasize and are invested in QIM. Corporate sustainability fosters results in terms of better problem tackling, better employee morale and better able to inspire cultural change [76]. The organizational capabilities where QIM is in place will empower the organization to focus on other aspects of the business for future sustainability and expansion.
- *Discipline enforcement*. Enforcing project discipline and standards throughout the PLC is vital to minimize errors in all aspects of IT projects and reduces risk of project delays and failure by addressing those issues before they arise. This proactive approach of process system checks involves balancing of cross-functional activities and tasks ensuring a set of standard guidelines. Any non-conformance will be corrected by benchmarking with the standards without wasting time and money figuring out solutions because a QIM would have defined standards and roles of responsibilities in place ahead of time when problems arise.
- *Competition with competitors*. To-date, there are many SMEs in Malaysia facing difficulties of sustaining a tender due to a lack of knowledge or proof in the area of quality management. The aggressive market pressure and trend (i.e. from main tenant, main developer etc.) have driven SMEs to acquire necessary skills and knowledge in the area of quality management. An empirical research by Kuei & Madu [37] revealed that in order to ensure product outputs are aligned with quality control, the key ingredient is to have vendor-supplier alignment in quality improvement methodology.

Table 8 The Reasons for QIM in Malaysia IT Industry [147]

Objective of QIM	Level of Influence (Importance)					Weightage	Order of Benefits
	Most (5)	(4)	(3)	(2)	Least (1)	f(x)	
Getting things right	9	7	1	0	2	78	1
Manage customer's expectation	7	8	1	0	0	70	2
Corporate Sustainability	6	8	2	0	0	68	3
Discipline enforcement	3	8	6	1	1	68	3
Competition with competitors	7	5	4	0	0	67	4
Require constant tracking	4	7	5	0	1	64	5
Symbolization of Quality	5	8	1	1	1	63	6
Trend	1	5	7	2	0	50	7
Vendor's Requirement	1	5	5	2	2	46	8
Market Pressure	1	6	3	2	2	44	9

Source: Research analysis compilation

2.2.4.3 Commonly Used Tools and Techniques

A set of commonly used tools and techniques are listed in random order to gauge the frequency of usage from the sample of surveyed companies [147]. Table 9 summarizes the frequently used tools and techniques (as a result of literature review [11, 36, 104, 151-153]) in the IT industry and a majority of the process and quality related problems in IT industry can be readily tackled using the simple problem-solving tools and techniques (in descending order of frequency) such as Flowcharts, Process Mapping, History/Pareto/Run/Line chart, Gap Analysis, Voice-Of-Customer (VOC), Data Flow Diagram (DFD), Cost Benefit Analysis, Cost-Of-Poor-Quality (COPQ), Statistical Process Control (SPC), Cause and Effect Diagram, Design for Experiments (DoE) etc.

In general, the role of tools and techniques has expanded from simply assisting business activities to managing, controlling and measuring its process. Organizations with mature processes tend to utilize relevant tools to better manage and improve their processes. In view of the research outcomes gathered from the survey findings (Table 9) that more than 90% (i.e. 20 out of 21 of commonly used tools and techniques gathered and compiled from the survey belongs to Six Sigma family[1]) of the tools and techniques used to implement and monitor continuous improvements in the surveyed companies are Six Sigma data-driven statistical and managerial tools; this QIM would be popular in the future. This means a majority of the surveyed companies are ready for Six Sigma implementation having already been applying the relevant tools and techniques related to Six Sigma but exploration of Six Sigma training (White- Belt, Yellow-Belt, Green-Belt or Black-Belt) for high-potential staff will still be required to ensure successful Six Sigma implementation.

Table 9 Commonly Used Tools and Techniques [147]

No	Tools and Techniques	Level of Influence					Weightage	Order of Benefits	Six Sigma Tools and Techniques
		very often (4)	Often (3)	some times (2)	rarely (1)	Never (0)	f(x)		
1	Flowcharts	8	4	2	0	0	62	1	Yes ; [11, 151]
2	Process mapping	7	6	0	0	0	59	2	Yes ; [104, 152]
3	History / Pareto Chart / Run Chart / Line Chart	7	2	1	0	0	46	3	Yes ; [11, 104]
4	Gap analysis	7	0	3	0	1	45	4	Yes ; [153]
5	Voice of customer analysis	6	2	2	0	0	44	5	Yes ; [152]
6	DFD (Data flow diagram)	1	8	0	3	0	43	6	
7	Cost Benefit Analysis	5	0	1	5	0	38	7	Yes ; [104]
8	Process Map	2	5	1	0	0	33	8	Yes ; [152]
9	Cost-of-poor-quality (COPQ)	3	2	1	2	0	30	9	Yes ; [104]
10	Statistical process control (SPC)	0	4	3	2	0	29	10	Yes ; [11, 104]
11	Cause and Effect Diagram	1	3	4	0	0	29	10	Yes ; [11, 151, 152]
12	Design for experiments (DoE)	0	5	1	1	0	25	12	Yes ; [36]
13	Gap Analysis	4	1	0	0	0	24	13	Yes ; [153]
14	Process capability analysis (PCA)	0	2	3	0	0	17	14	Yes ; [104]
15	Correlation Analysis	0	2	1	3	0	17	14	Yes ; [104]
16	Regression Analysis	0	2	0	4	0	16	16	Yes ; [104]
17	Earned Value Analysis (EVA)	1	1	0	3	0	15	17	Yes ; [104]
18	Two Sample T-Test	1	0	1	3	0	14	18	Yes ; [104]
19	Affinity Diagram	0	0	3	2	0	13	19	Yes ; [104]
20	SIPOC Diagram	0	0	3	2	0	13	19	Yes ; [152, 153]
21	Spider Charts	0	1	1	3	0	13	19	Yes ; [11]
22	ANOVA	0	0	2	3	0	12	22	Yes ; [11]
23	Taguchi methods	0	0	1	3	0	9	23	Yes ; [11]
24	Kano Analysis	0	0	1	3	0	9	23	Yes ; [104]

Source: Research analysis compilation

2.2.4.4 Common Measurement Metrics in the IT Industry

The measurement matrices captured from the survey in the descending order of importance are:

i) Customer Satisfaction – Results of customer feedback
ii) Timeliness – Ability to deliver on time
iii) Reliability – The measure of uptime versus downtime
iv) Compliance – Ability to meet product specifications
v) Responsiveness – Ability to respond to requests quickly
vi) Defect Counts – Warranty, maintenance, recall, repair

[1] The literature review of Six Sigma tools and techniques was discussed in Chapter-3, section 3.5.2 Table 23.

vii) Variation – Difference between planned and actual schedules
viii) Acceptability – Aesthetics, usability, functionality, etc.

However, respondents were given the opportunity to share their measurement matrices in an open-ended question. All answers were pre-coded according to discussion topics listed in Table 8. The summarized measurement metrics for IT related non-conformance of quality activities can be outlined as follows:

- *Defect Counts*: Numbers of bugs and issues in the course of a specific software release. This is inclusive of pre-released and post-released defects. This area of non-conformance contributed 40% of total surveyed statistic and some examples of defects counts are warranty claims, maintenance effort, product recall, product repair etc.
- *Reliability:* Total down-time captured when the system goes live contributes 20% of common measurement metrics for non-conformance. The sponsor's tolerance level of down-time is very low as down-time is expensive and is always measured with dollar and cents per second especially pertaining to real-time systems like banking systems, airline systems, investment and financial related systems.
- *Variation*: Twenty percent of the measurement metrics are basic measures, i.e. to track the differences between plan and actual project scheduling, budgeting/costing, project controlling and project tracking. Any differences between plan and actual QA and QC activities will result in project delayed/slippage, cost overrun/over-budget, not meeting user requirements which will further lead to motivation and team work issues.
- *Acceptability/Compliance*: The ability to meet product specifications either functionally, usability or aesthetically contributed 10% to measurement metrics of non-conformances.
- *Customer Satisfaction*: This can be measured via customer feedback through the helpdesk system capturing the volume of customer query, complaint, feedback etc. Though the measurement matrix only captured 10% of the measurement metrics, customer satisfaction has gained much attention and popularity amongst the Customer Relationship Management (CRM) industry.

2.2.4.5 Primary and Secondary Measureable Benefits

A set of primary and secondary measurable benefits gathered from the literature review [106, 154] was shortlisted in the online questionnaire. The levels of primary measurable benefits (i.e. percentage) are provided by respondents which gathered during the online survey. The recorded primary measurable benefits gained by surveyed companies from the implemented QIM in descending order are: (1) Increased customer satisfaction by 10%-20% ; (2) Reduced customer complaints by 40%-70% ; (3) Reduced software bugs by 10%-25% ; (4) Increased efficiency and effectiveness of decision making by 10%-15% ; (5) Reduced cycle time by 20%-40% ; (6) Reduced transaction error by 5%-10% ; (7) Saved project budget ; (8) Saved data merging time ; (9) Saving of RM 0.5million etc.

Nevertheless, the secondary measureable benefits gained from the continuous implementation of the quality improvement initiative (in descending order) are “improved efficiency and effectiveness”, “improved cross functional team work”, “improved project management process”, “improve company’s reputation”, “improved employee’s motivation”, “ability to retain customer”, “improved employee’s morale”, “ability to foster customer loyalty” etc.

2.2.4.6 Project Authority

The nature of project authority is slightly different in the IT industry. According to findings from the online survey, Project Manager and Project Leaders have the most authority in the project decision making process, followed by departmental manager/directors. Both project/product champion and project sponsor has the least authority. Project Manager (PM) and Project Leader (in the absent of PM) has the formal or legitimate authority to act in the name of sponsoring executive or on behalf of the organization.

PM needs to be empowered with authority to better plan for positive project outcomes and project-related deliverables. Project authority is an essential input of the ability to make binding decisions about a project’s products, schedule, resources and activities [155]. This is one of the important criteria to enable a PM to better manage, control and track a project.

2.2.4.7 Pre-QIM Training

More than 20 of the surveyed companies included a QM introductory course during their staff induction program. QM introductory course is one of the compulsory events for new reporting staff during the orientation week where staff are briefed and introduced to the importance of QIM in the company and respective team members’ responsibilities towards project quality.

The training duration collected from the survey varies between companies ranging with half day (17%), one day (25%), two days (17%), three days (25%), four days (8 days) and more than 5 days (8%) depending on the adopted QIM. Top management should provide appropriate training and motivating environment to foster teamwork both within and across organizational units for employees to improve processes [156]. This approach of pre-QIM training contains the top management’s intentions for operating the QIM of the organization. It encompasses quality policies concerning the adopted quality system, either affected by or affecting the mentioned quality system.

2.2.4.8 Non-Existence of Quality Assurance Department

It was surprising that all surveyed companies did not have an independent QA department or QA personnel managing in handling day-to-day quality operations. The task of QA falls onto the project team members where selected team member(s) is required to handle the QA part of the project despite his/her daily routine and responsibility as a project manager, project leader, project developer or tester etc. 23 (i.e. 62%) of the surveyed companies involved five to seven project team members in daily QA activities; leaving the remaining surveyed companies engaging one to four team members for respective project QA responsibilities.

In short, QA related responsibilities in Malaysia's IT industry fell on the shoulder of project team members with senior executives (Project Manager, Project Leader, System Analyst, Business Analyst etc.) taking the lead in routine QA activities. The senior team members were expected to oversee overall project strategy, establish requirements and performance expectations, manage the contract, monitor and assess performance and proactively anticipate and resolve issues that impact project success. Due to this reason, it is common to include project related QA activities as a KPI in an annual performance appraisal.

2.2.4.9 Resistance Factors for QIM Implementation

According to a case study research by Brietzke [157] and Nasir [64], resistance factors in software process improvement can be categorized into two categories: (1) Organizational-related factors, (2) Project-related factors. A detailed literature review was conducted between different QIMs to identify various resistance factors and a list of "Common-to-All" resistance factors were defined and were used to devise the survey resistance-factors questions.

Organizational factors inclusive of 'lack of commitment', 'lack of teamwork and participation', 'cynicism and resistance to cultural change', 'lack of support from senior management' and 'lack of proper training and knowledge'. Other organizational factors include 'lack of established policies and goals' and 'improper translation of quality improvement processes to suit the organization's needs'. Under project factors, the listing of resistance factors is 'budgets and estimates' and 'documentation'. It can also be noted that it is critical that all the initiatives considered in this study be viewed as a framework rather than a set of step-by-step guidelines, and that the process needs to be catered to each individual organization's needs.

Table 10 summarizes the top ten (in descending of importance) resistance factors in Malaysia's IT industry with 'organizational factors' dominating research findings, contributing nine out of ten barriers while the remaining resistance factor comes from the project factor category. Furthermore it can be seen that 80% of the barriers can be directly linked to managerial responsibility. This could be translated to mean that the Malaysian IT sector needs to focus on improving organizational management approaches and planning in order to achieve optimum results. In summary, more attention and emphasis from the management aspect is important for QIM implementation. The survey results are concordant with literature by Nasir [3] and Brietzke and Rabelo [35] where the three key resistance factors needed to be addressed were: (1) Lack of leadership, skill and professional knowledge in implementation; (2) Lack of support from senior management; (3) Lack of clear goals and objectives.

Table 10 Top 10 Resistance Factors [147, 158]

No	Resistance Factors	Weighted Score	Organizational Factor	Project Factor
F01	Lack of leadership, skill and professional knowledge in implementation	812	√	
F02	Lack of support from senior management	774	√	
F03	Lack of clear goals and objectives	774	√	
F04	Insufficient training and awareness for individuals in ALL levels in the organization	710	√	
F05	Costs higher than budgeted	662		√
F06	Lack of clear organizational and/or quality policies making intentions clear regarding quality improvement initiative	641	√	
F07	Insufficient analysis of current situation of software process	610	√	
F08	Failure to conduct an initial analysis checking if organization required the implementation of this particular initiative	565	√	
F09	Implementation is counterproductive; causes distraction from more urgent needs	533	√	
F10	Lack of teamwork and participation among members of ALL levels in the organization	493	√	

Source: Research analysis compilation

2.2.4.10 Quality Solution for QIM Implementation

Organizational leadership is the main responsibility of upper management. When new projects are proposed, it is important that an organization's senior management team demonstrate that they are in full support. Project teams appreciated having unlimited access to senior managers and top management in seeking advice, sharing new information or making decision [159]. In such situations, the team members are always informed of new initiative(s) and will be in full support of the new initiate(s); and they also will motivate and encourage other project teams. Importantly, a responsible and proactive leader is required to initiate any change. A quality team leader could be an experienced project manager, a skilled software engineer, or the head of the human resource (HR) team. The leaders need to be a reliable advisor with sound problem solving skills and firm determination, especially in stressful situations [160].

Managers need to be more approachable and take on greater encouraging role. Many problems arise and may remain unaddressed if the employees are afraid of approaching higher management. Research shows junior employees tend to hide bad news from higher management [161]. Senior management playing a more active role might also act as a source of encouragement and add a level of importance to the initiative [157, 160]. In Malaysia, according to the results obtained and studies by Nasir [64], failure to do so is seen as a very significant barrier to the successful implementation of Quality Management in the IT sector. A supportive manager exists when subordinates are able to report their failures without fear of the consequences. This entails giving the employees a greater control over their work, while providing guidance and considering their involvement valuable.

It is important to establish clear goals and objectives. Setting realistic goals on a time, quality and cost basis is crucial as the QM is a long term endeavor which takes much effort and resources to realize the benefits. A set of clear goals and objectives give a sense of purpose towards organizational directive and help keep organizations on track. Prioritization of improvement areas should be taken seriously with focused resources and well-defined goals and objectives. This will ensure there is no disappointment or loss of morale in that arena.

Most of the Performance Appraisal (PA) systems in the IT industry are designed to encourage the commitment of middle management to the success of QA implementation where companies align the QA benefits as part of the key performance index (KPI) in the annual PA system. The findings revealed that about 30%-50% of total KPI for majority of Project Managers, Project Leaders and Business Analyst are allocated to respective project quality assurance matters and project team members have 20-30% of KPI allocation to QA matters.

From the findings, it was concluded that the percentage of QA as KPI in performance appraisal has positive relationship with project role; the more senior the project role, the higher the KPI contribution in individual PA system. In conclusion, proportion of KPI contribution in the PA system is a critical success factor for successful QIM implementation in the Malaysian IT industry. This is supported by the evidence that about 50%-60% of respective individual project time allocation is needed in handling, managing and controlling the quality of project output.

IT Service, IT Product and IT Process providers are struggling to compete among each other, battling to retain existing customers by lending ears to their complaints and yet having to fulfill customers' endless demands and requests. Nevertheless, everyone would agree that the transition from this decade to the next is a time of massive and unpredictable change which demands IT companies of various sizes to place attention on a quality-based approach that gives corporations the ability to successfully execute projects time after time.

In a little over ten years, Six Sigma has quickly become not only a hugely popular methodology used by many corporations for quality and process improvement, it has also become the subject of numerous training and consultancy products and services which spawned an abundance of Six Sigma support organizations [74]. Figure 3 and Figure 2 show that Six Sigma has slowly gained the market's confidence and popularity as a QIM among the IT companies; and for years to come. Six Sigma is a recent initiative adopted by most IT organizations as a performance improvement initiative (attacking at least one of the Cost, Quality, Delivery, Satisfactory, and Sustainability measurements for improved competitiveness) [47, 77].

A total of the 19 respondents from a pool of 37 had contributed their inputs to the question of "Six Sigma awareness in the IT industry", as depicts in Table 11. The findings reveal that majority of the Six Sigma supporters (existing users) DO NOT view "Six Sigma as a cost" but rather see Six Sigma as an opportunity (92%) in QIM implementation. Besides, a consistent, coherent and positive outcome was obtained between these two groups (existing Six Sigma users and non-Six Sigma users), acknowledged Six Sigma as a fact rather than a fad; and also view Six Sigma as a possible trend to be adopted in the near future. This strongly supports the hypothesis of Six Sigma to be the next in-line QIM in Malaysia's IT industry for years to come.

Table 11 Six Sigma Awareness in Malaysia's IT Industry [13, 80]

QIM Users	An Opportunity		A Cost		A Passing Fad		A Possible Trend to Adopt	
	Agree	Disagree	Agree	Disagree	Agree	Disagree	Agree	Disagree
Existing Six Sigma User (12)	92%	8%	17%	83%	0%	100%	92%	8%
Non Six Sigma User (7)	29%	71%	57%	43%	29%	71%	57%	43%

Source: Research analysis compilation

The future of the IT world is full of challenges. Not only is there a growth in the use of individual standards and frameworks but many organizations also implement several frameworks simultaneously. Many qualitative or quantitative researches related to the implementation of multiple process improvement frameworks (either is existent or virtually non-existent) are creating daunting challenges for IS management in many respects. It especially demands changes of the external and internal IT environment.

2.3 The Shift of IT Quality Improvement Methodology Selection

Advanced companies today are in search of business excellence to meet the challenges of globalization in all market segments. The traditional method of QIM which focuses on quality assurance lacks a consistent, predictable, and repeatable approach to IT quality management throughout the software development lifecycle, often resulting in projects that are destined to run over budget, miss deadlines, and fall short of customer expectations [93].

The last two decades has witnessed an increased pressure from customers and competitors for greater value from their purchase whether based on quality, faster delivery, or lower cost (or the combinations) in both manufacturing and service sector [162]. This has encouraged many industries (manufacturing and non-manufacturing) to integrate or align two or more QIMs as part of management strategy to increase market share and maximize profit. Companies across the spectrum have found that the most effective way to eliminate the flaws which lead to rework and scrap, and create one unified idea of continuous improvement, is the integration or aligning two or more systems to achieve much better results than a single system can achieve alone. The integrated methodologies emphasize unfathomable involvement of top executives and communication with the bottom line to develop robust products and processes in the respective organizations [162].

2.3.1 The New Paradigm Shift of QIM Selection

These days, there is an emergent paradigm shift of adopting Six Sigma as the upcoming QIM because **Six Sigma** is often considered the "**modern form of quality management**". The success stories of Six Sigma have attracted many well-known organizations like Siemens, Nokia, Volvo and Ford etc. into its quality system implementation [163]. Six Sigma goes beyond manufacturing and over the last two decades, Six Sigma has gained in popularity covering a vast array of industries especially into the business areas of IT processes, products and services.

Source: Research analysis compilation

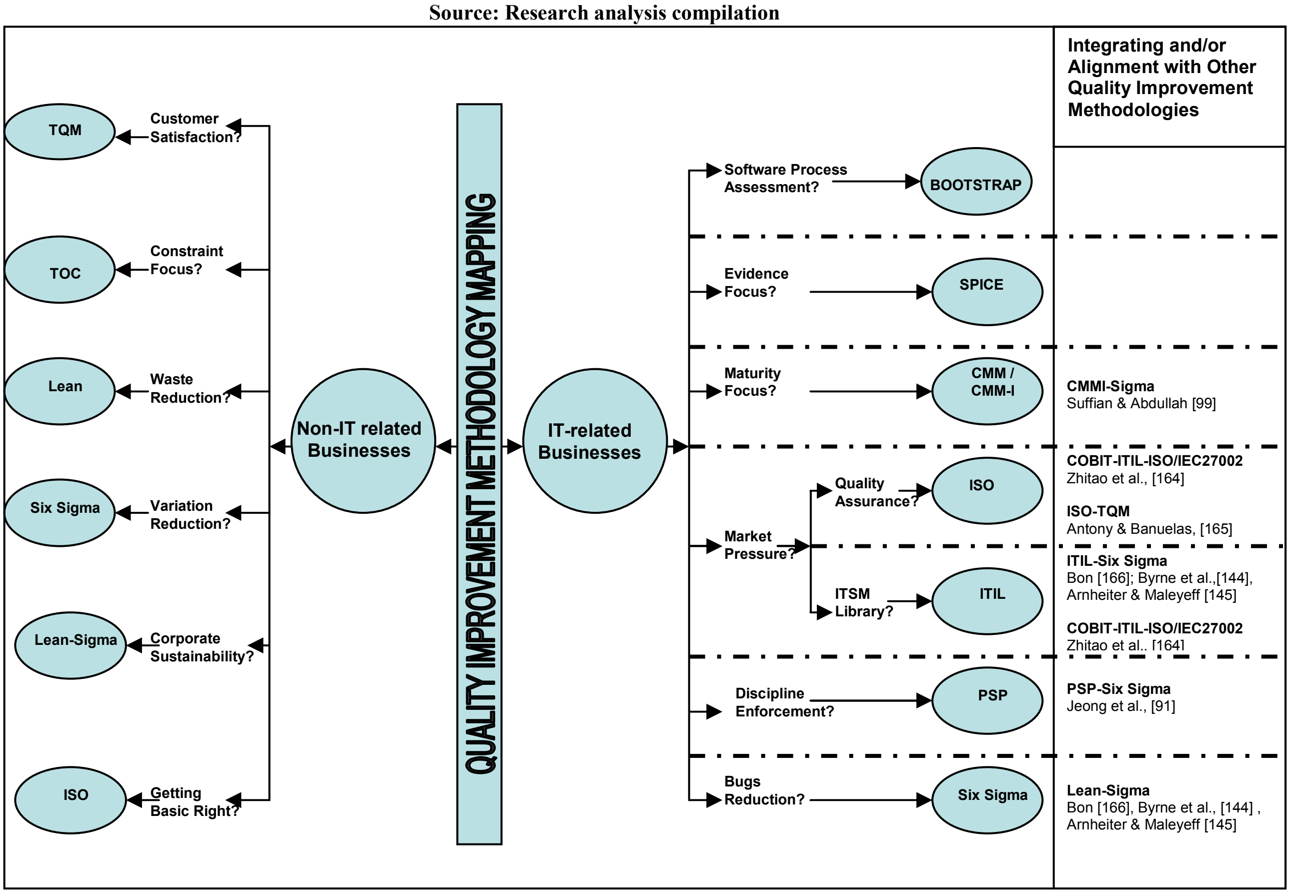


Figure 4 The Combination Matrix Mapping of QIMs [13, 80]

A comprehensive literature reviews highlighted the degree of integration in various combinations of QIM as shown in Figure 4. The globalized world and emerging technologies are imposing an enormous impact on organization's operation routine causing an exponential upsurge of stress and burden while prompting stiff competition in the market place. Figure 4 outlines the shift of CMM/CMM-I, ISO, ITIL, PSP and Six Sigma are among the QIM integrated with other QIM. These different combinations of integrated QIM can help generate business results that are at once concrete, consistent, measurable, and sustainable. Moreover, the time frames to transform a conventional organization to an integrated QIM vary tremendously across industries, and even across firms in the same industry. Even the metrics used to gauge a firm's progress toward an integrated QIM vary widely. Therefore, it is necessary to create awareness among IT management teams to think forward of a new mandate approach in IT quality management without having to drop existing QIM for a new face-lift migration to cope with business objectives. This can be achieved by integrating a new QIM which addresses most weaknesses of current QIM and retaining most of the strengths to current business routines. This approach aims to enhance the bottom-line results by extending focus of quality management effort to quality control and continuous quality improvement.

In most cases, the existing QIM which serves well in the day-to-day operational and procedural business activities should be maintained and retained as it has already become part of the organization's culture. It is important to explore other QIMs which address existing weaknesses and limitations in view of continuous improvement. This method of migration approach integrating and aligning other QIM not only retained existing cultures and norms, but the organization moves forward and achieve a higher level of maturity in QM through focusing on a different set of demanding user expectations and user requirements. In short, organizations should move their development from narrowly-focused, traditional QIMs to a lifecycle approach of integrating with other QIMs which enforces "continuous improvement". Table 12 are some reviewed evidences from the practitioners of integrating and aligning different combinations of QIMs to better manage and control the quality of IT processes, products and services.

Table 12 Evidences of Six Sigma Integration with other QIMs

No	Evidence
1	Antony & Fergusson [16] revealed that Six Sigma and CMM are complimentary and mutually supportive and Six Sigma could be an enabler to launch CMM depending on current organizational or individual circumstances. MIMOS Software Production Process has successfully integrated Six Sigma and CMM-I to establish a Defect Prediction Model for system test phase in early prediction of functional defects in PLC rather than capturing ample defects at the later stage of the testing phase [57].
2)	Seow & Jiying [77] has undertaken a qualitative research study in a food and beverage SME organization in Malaysia exploring how customizing and alignment of Lean-Six Sigma deployment has improved equipment reliability, made positive significant savings in lead times and customer delivery, and winning of new supermarket contracts. When Lean principles are integrated with Six Sigma practices, their success rate grows; and most importantly, improvements become embedded in daily work life on a continuing basis [83].
3)	A battery company (Baxter Battery) instituted the blend of Six Sigma methodology in conjunction with Lean solution, and dramatically reduced its capital cost ($20 million) while streamlining its manufacturing process (specifically in lead plates used to build batteries), as well as improving its customer satisfaction levels [83].
4)	Byrne et al., [144] being the Americas Group Lean-Six Sigma Leader for IBM revealed some leading companies (e.g. Caterpillar Inc.,) implemented operations strategies based on Lean Six Sigma management techniques with the objective of establishing disciplined working environments focused on customer needs, detailed data analysis and facts, not theories. The author sees Lean Six Sigma approach focusing not just on efficiency but also on growth, it can serve as a foundation for innovation throughout an organization. The Lean-Six Sigma program is not just about "doing things better", it is a way of "doing better things". Furthermore, if Lean-Sigma is used effectively, it can enhance innovations in products, services, markets and even a company's underlying business model, as well as improve operations [144].
5)	On the other hand, a number of researchers are aligning ITIL-Six Sigma with the objective that Six Sigma techniques can be applied to ITIL in bringing the engineering approach to ITIL's framework [18, 34, 65, 76]. The reason behind this is that ITIL itself is not a transformation method, nor does it offer one. ITIL does not provide usable methods that are "out of the box" to measure customer satisfaction like Six Sigma does. Chan at al., supports the adoption of Six Sigma principles into ITIL as this new combination helps IT to focus on their customer and the business strategy is more proactively based on facts and reinforce collaboration across the enterprise [65].
6)	Another good example would be GE engaged in the IT Solution Enterprise Planning & Strategy consulting group to develop a process improvement methodology, combining ITIL and Six Sigma to migrate from the current state to "measurable, ITIL-Sigma compatible processes" for its' ITSM system [65].
7)	Even PSP has been likened to applying Six Sigma toward Software Development [58]. Both PSP and Six Sigma are emerging as efficient tools to improve software processes with PSP-Six Sigma being one of the mutually complementing software process improvement methods [58]. Deploying PSP in conjunction with Six Sigma can provide the quantitative analysis capabilities to identify high leverage activities, evaluate the effectiveness of process changes, quantify cost and benefits, and control process performance. In short, despite the fact that PSP and Six Sigma can be utilized independently, there is a definite and significant synergy between them [59].

Source: Research analysis compilation

Table 13 the collective outcomes of most recent studies that demonstrate different combinations of QIMs integration. The result clearly demonstrates the increasing likelihood of Six Sigma as one of the most popular quality improvement initiatives being integrated with other QIM. This upcoming trend of adopting Six Sigma principles into the improvement mix of existing QIM, has made it possible to put business process framework in place and leverage the benefits from one process to other processes in an organization [83]. Furthermore, process improvements generated in one area can be leveraged elsewhere (e.g. cross-department) to maximum advantage, resulting in a quantum increases in product quality, process improvement, and corporate earnings performance [83].

Six Sigma is not something, but many things that is "all in one". Six Sigma is a methodology, a management system, and a metric all at once, making it a very useful and popular tool for businesses of all sizes. Once the variations in business processes, services and products are reduced; the chances of faults, mistakes, dissatisfactions, bugs and other disqualified measurement should also reduce to a manageable and bearable level (e.g. *n*-level). The existing process will continue in seeking for the next round of continuous improvement to further reduce the *n*-level to a lower level. This is the main reason why Six Sigma has been applied beyond manufacturing and into the field of IT for the past few decades.

Table 13 The combination Matrix of Different QIMs [13, 80]

Quality Improvement Methodology	TQM	TOC	Lean	BOOT-STRAP	SPICE	CMM / CMM-I	ISO	ITIL	PSP	Six Sigma	CORBIT
TQM							[164]				
TOC											
Lean										[165], [144], [145], [83], [162], [166], [48], [167], [131], [23], [22], [68], [76], [168]	
BOOTSTRAP											
SPICE											
CMM / CMM-I								[63]		[57]	
ISO											[169]
ITIL										[165], [144], [145]	
PSP										[58]	
Six Sigma											
CORBIT											

Source: Research analysis compilation

2.3.2 What is So Special about Six Sigma?

Six Sigma process always strives to achieve the best-in-class level of quality [11]. Overtime, Six Sigma has gained popularity and prominence as an effective quality improvement technique after it was successfully implemented in Motorola. Since then, many large organizations like GE, 3M, and Allied Signal etc. have implemented Six Sigma programs and improved the quality of manufactured goods, services and processes rendered.

The Six Sigma methodology provides a proactive and consistent data-driven approach to solving difficult business problems [65, 83]. This statistically based problem-solving methodology of Six Sigma delivers data to drive solutions, delivering dramatic bottom-line results [162]. Six Sigma uses mathematical and statistical tools to model problems in business settings, determine the root causes of problems, develop and implement solutions, capable of putting statistical controls in place to prevent the problems from arising again and takes an organization to an improved level of process performance and capability [83, 162]. Because Six Sigma relies on probability, statistical measurement techniques, and systematic data gathering, it is a powerful decision-making and analytical tool [83]. Furthermore, Six Sigma combines the variability of reduction tools and techniques with other QIM to generate savings to the bottom-line of an organization [162].

Six Sigma's uses of the comprehensive set of tools mentioned above can help to reduce all kinds of waste (rework, over production, waiting, material, human skills, transportation and unnecessary movement) from the organization. Besides, Six Sigma uses the DMAIC methodology for problem solving which successfully integrates a set of tools and techniques in a disciplined fashion [162]. Six Sigma methodology is a highly disciplined and statistically based approach for removing defects from products, processes, and transactions, involving everybody in the corporation – has been adopted as a major initiative by some of our leading companies. This is fundamentally changing the paradigm of how statistics is applied in business and industry, and has had a career-changing impact on those statisticians who have been involved. More importantly, the technical definition and concept of Six Sigma is a disciplined, quantitative and qualitative approach for quality improvement based on defined metrics in manufacturing, service, or financial processes [170].

Implementing Six Sigma alone has created many success stories and dramatic results in various industries such as banking [19], healthcare [20, 21], leisure service quality [26], internet service provider [24], retailing [28] etc. This clearly proved that Six Sigma indeed has great potential and is worth the effort and time to further explore and investigate. The success stories of Six Sigma implementation in various industries especially in the field of IT Project Management has given a high-level of confidence to companies which have yet to adopt or partially integrate Six Sigma as part of the company quality management system. The upcoming Six Sigma implementation is not limited to manufacturing, but has expanded and gradually penetrated into the non-manufacturing sector especially IT industry with or without public awareness in many countries [171].

2.3.3 Six Sigma Quality Beyond Manufacturing

Although most of the initial emphasis of Six Sigma was for quality improvement in manufacturing, it is now being applied in key areas beyond manufacturing, and beyond what would traditionally be considered "quality". Emphasis in these areas has, in fact, recently accelerated with the aim of ensuring that customers also reap the benefits of Six Sigma. For example, AlliedSignal has developed its commercialization thrust around Six Sigma concepts, voice of the customer, value chain analysis, and customer satisfaction. The focus is on getting good data on customer requirements, and on reducing failures and variation in product design, scale-up, and commercialization. AlliedSignal also has significant Six Sigma initiatives ongoing in financial and business services [170].

In particular, Six Sigma can be implemented into the era of product, service and process of IT sector in Malaysia. The shift of Six Sigma implementation in IT is no longer emphasized on acceptable defect levels but on tackling the problems that caused the defects. Three things to remember whenever one think about Six Sigma, i.e. Reducing Process, Product and Service Variation; Simplifying Product, Service and Process Design; Look at your offering from customers' perspective [172]. In short, it is all about "Complexity, Variation and Customer". However, "Customer satisfaction" is not enough as "very satisfied" customer are six times more likely to repurchase than "satisfied" customers. It is important for companies to know which features and factors are satisfying or delighting their customers. Even if some functions are outsourced to third parties, it is the responsibilities of the company to ensure the outsource companies are aligned and equipped with necessary skills and knowledge of QIM [172].

Over the last twenty years, the scope of Six Sigma is also much broader than other quality management programmes as it can be applied to every business process of an organization. The future is bright for Six Sigma programmes with the growing awareness in SMEs about the potential benefits that can be derived from implementing such programmes. Six Sigma invigorated quality by transforming bottom lines positively, company after company. Some of the cynical views against Six Sigma appear to have been triggered by companies that have looked at quality in theory, and not based on results. Any quality system without data-driven results is "quality on paper". Six Sigma has the potential to transform the business environment and customers, are the ultimate benefactors of its results both in the manufacturing and non-manufacturing industry. This clearly shows that Six Sigma indeed has great potential in the area of IT project management where this research project is to further explore and investigate.

2.4 Chapter Summary

This chapter analyses and identifies the current practice and trends observed in successful QIM implementation in the Malaysia IT industry, based on literature as well as qualitative and quantitative research. It highlights Malaysia's culture in QIM implementation and identifies important areas of consideration relevant to adoption of QIM. This chapter also attempts to provide quality solutions to overcome or reduce the effect of the mentioned resistance factors during QIM implementation in the Malaysia IT industry especially for the SMEs sectors. Though the solution presented may not encompass an overall holistic view representing all SMEs in the IT industry, the gathered and tabulated data from the survey served to highlight important views and provide guidelines for any IT company to be aware of when embarking on quality objectives. This will reduce the risk and learning curve prior to adopting or implementing any QIM. This topic has not been discussed in previous publications and therefore is useful for new-comers to the IT industry.

In summary, Six Sigma implementation in Malaysia's IT industry has been theoretically justified with literature reviews and discussed practically against survey outcomes. Any Malaysian IT organizations seeking to boost business performance should start considering Six Sigma in their business establishment; either as a new QIM adoption or opt for integrating Six Sigma with existing QIM focusing on identifying, quantifying, and driving out error in business processes to maximize business earning in the long run.

Chapter-3 The Six Sigma Way

3.1 Introduction

As Six Sigma introduction and implementation requires significant resources and financial (case-to-case basis) commitment, it is important to know where, when and how to adopt Six Sigma initiatives in respective companies. It takes much effort and time from both the top management and different operational levels to plan and to put Six Sigma into action. Hence, Six Sigma is something a company has to "feel" that it really needs. Six Sigma is not about prescribing or imposing a preconceived formula on an organization from the outside (consultant), the drive has to come from within the company and no other parties, or Six Sigma won't work [172].

When Six Sigma comes into play, rapid development and deployment of breakthrough solutions are needed. Many methods of Six Sigma are familiar to readers ranging from statistical to management and planning areas that are in vogue in an environment where teamwork, continuous improvement and breakthrough thinking are valued. Fundamentally, Six Sigma is about changing an organization's culture and the way things are done. It is a structured knowledge-acquisition and problem-solving approach known as DMAIC (Define, Measure, Analyze, Improve and Control). Six Sigma can assists in honing the missions of mercy or service that such agencies are intended to bring to individuals and communities [50]. According to Paul [173], Six Sigma became the battle cry leading a strong drive not only to reduce defects, but to shorten cycle time and achieve near zero-defect quality.

3.1.2 The History and Historical Development of Six Sigma

The success of the efforts at Motorola was not just achieving Six Sigma quality level rather the focus was on reducing defect rate in the process through the effective utilization of powerful and practical statistical tools and techniques [14, 29, 73, 164]. In 1985, a quality manager Bill Smith (Motorola) proposed the use of the sigma capacity as a common metric of quality measurement performance. Ten years after implementing the method, Motorola has tripled its productivity and reduced the production cost up to US$11 million. Others companies implementing Six Sigma are Asea Brown Boveri, Texas Instruments, Allied Signal, GE, HP (Hewlett-Packard), Polaroid and Citibank. It was through GE that Six Sigma received recognition internationally. Between 1997, GE invested US$450 million on its implementation and in 1999 obtained productivity gains around US$1.5 billion [29].

Most people attribute Six Sigma's astonishing success to GE, which in 2002 stated that they had achieved US$8 billion in cost saving since 1999. In the late 1990s, many subsidiaries of US corporations began to demand Six Sigma quality from their suppliers [18]. By 2004, Six Sigma had become a truly global phenomenon and was firmly established in all industry sectors. In the

2005 Six Sigma Summits held in London and Amsterdam, over 50% of the delegates came from outside of the manufacturing sector [18].

There are pools of business articles and research papers discussing the progress and evolvement of Six Sigma implementation over the past decades and Table 14 summarized the historical development of Six Sigma implementation:

Table 14 Summary of Historical Development of Six Sigma Implementation

Year	Historical Summary
1920's	The word 'sigma' has been used by mathematicians and engineers as a **symbol for unit of measurement in product quality variation**. Note: It is sigma with a small 's' because in this context sigma is a generic unit of measurement.
1980	• Bill Smith, one reliable senior engineer in **Motorola** created the most original Six Sigma reports under the supervision of President Bob Galvin [110]. • Slogan in the early 80's: "Zero Defects" [173]
1985	• Bill Smith proposed the use of sigma capacity as a common metric of quality measurement performance. [29] • In the **mid-1980's,** engineers of Motorola Inc in the USA used 'Six Sigma' an **informal name for an in-house initiative for reducing defects in production processes**, because it represented a suitably high level of quality [74]. • In the **mid-1980's,** Motorola was the first company to launch a Six Sigma program [40]. Note : Here, it is **Sigma with a big 'S'** because in this context Six Sigma is a 'branded' name for Motorola's initiative.
Late 1980's	• In the **late-1980's** following the success by Bill Smith or Mikal Harry, Motorola extended the Six Sigma methods to its critical business processes, and significantly Six Sigma became a formalized in-house 'branded' name for a performance improvement methodology, i.e., beyond purely 'defect reduction', in Motorola Inc. [74] • In the **1988,** Motorola received the national recognition by winning the first Malcom Baldrige National Quality Award, which led to an increase interest of Six Sigma from other organization [40], [173]. • By 1989, IBM adopted the Six Sigma approach and began to spread and share the techniques of Six Sigma throughout the corporation [173].
1990	• Quality control concept entered into the age of "Total Quality Management" (TQM). But due to lack of experience, the management level implemented the concept of TQM from the top to the bottom, which caused the failure and the waste because of non-transparent objectives. [110] • From the **1990** onwards, Six Sigma processes was adapted to the non-manufacturing areas of the Motorola company [41]
1991	• Motorola certified its first 'Black Belt' Six Sigma experts, which indicates the beginnings of the formalization of the accredited training of Six Sigma methods. [74] • **Allied Signal** (a large avionics company which merged with Honeywell in 1999), adopted the Six Sigma methods, and claimed significant improvements and cost savings within six months. It seems that Allied Signal's new CEO Lawrence Bossidy learned of Motorola's work with Six Sigma and also approached Motorola's CEO Bob Galvin to learn how it could be used in Allied Signal.
1995	• **General Electric**'s CEO Jack Welch (Welch knew Bossidy since Bossidy once worked for Welch at GE, and Welch was impressed by Bossidy's achievements using Six Sigma) decided to implement Six Sigma in GE, and by 1998 GE claimed that Six Sigma had generated over three-quarters of a billion dollars in cost savings. [174], [74] • By the **mid-1990's** Six Sigma had developed into a transferable 'branded' corporate management initiative and methodology, notably in GE and other large manufacturing corporations, but also in organizations outside the manufacturing sector [74]
2000	• By the year **2000**, Six Sigma was effectively established as an **industry in its own right, involving the training, consultancy and implementation of Six Sigma methodology** in all sorts of organizations around the world [74] • Motorola integrated the concept of Six Sigma and process quality management, which proved the benefit to ensure improved quality. Motorola then carried out this revolutionary introduction and implementation extensively. Using Six Sigma, Motorola not only made the important improvement in quality and associated processes, but also emerged as one of the prestigious worldwide business. [110]
2003	Motorola has applied Six Sigma concept to all department internally within the entire enterprise, and institutionalized it into what we called "functional collaborative model" [37].
There after…	Six Sigma has expanded its capability and competency in the industries of banking [19], healthcare [20, 21], leisure service quality [26], internet service provider [24], retailing [28] etc.

Source: Research analysis compilation

That is to say, in a **little over ten years**, Six Sigma quickly became not only a hugely popular methodology used by many corporations for quality and process improvement, Six Sigma also became the subject of many varied training and consultancy products and services around which developed very many Six Sigma support organizations.

3.1.3 Six Sigma Belt Hierarchy System and Six Sigma Training

Teams and team leaders are an essential part of the Six Sigma methodology. Six Sigma is therefore a methodology which requires and encourages team leaders and teams to take responsibility for implementing the Six Sigma processes. Training is therefore also an essential element of the Six Sigma methodology. Six Sigma teams and notably Six Sigma team leaders ('Black Belts') use a vast array of tools at each stage of Six Sigma implementation to define, measure, analyze and control variation in process quality, and to manage people, teams and communications.

The "Warrior Class" system with different color belts denote people with different levels of expertise (and to an extent qualifications), and different responsibilities [110]. Belt hierarchy system ensures that the transfer of method to its first application is effectively implemented. Figure 5 show an overview of Six Sigma Hierarchy System, a typical "Warrior Class" includes Champion, Master Black Belt, Black Belt and Green Belt [110]. The roles of respective Six Sigma players in the "Warrior Class" are discussed in Table 15.

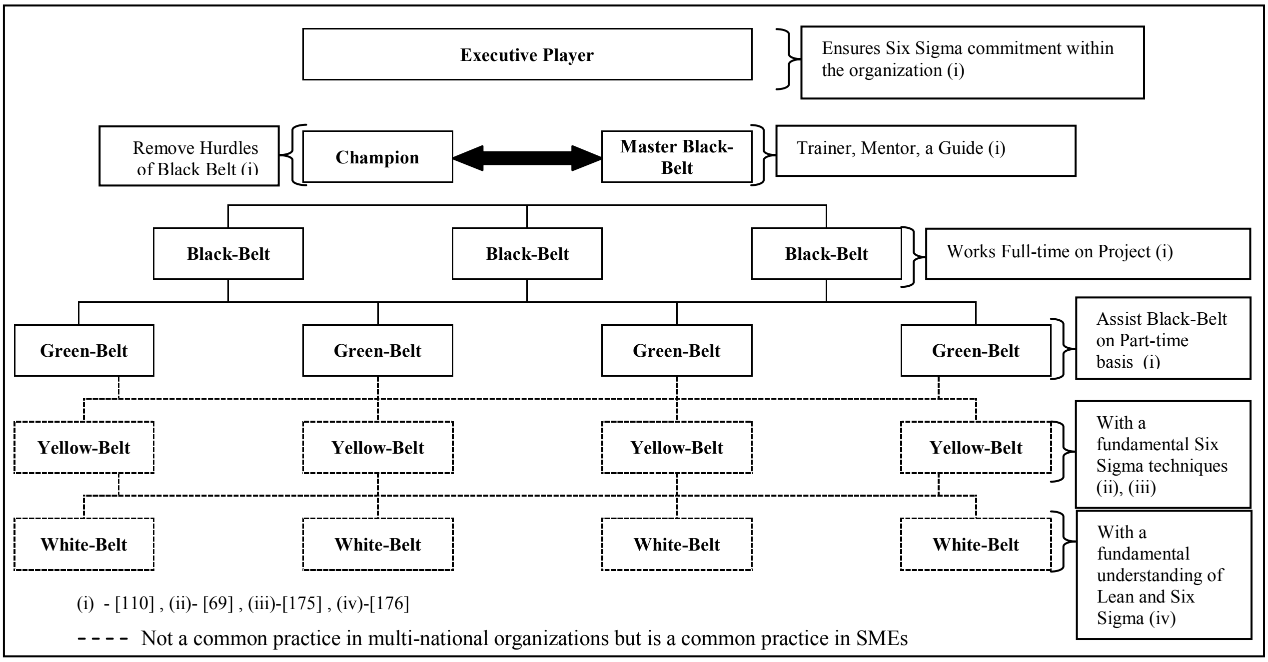


Figure 5 The Six Sigma Belt Hierarchy System [110]

One of the main obstacles of implementing Six Sigma is the resources and financial commitment in Six Sigma certification. To overcome traditional top-down black-belt Six Sigma implementation, a methodology of "**Yellow Belts**" and "**White Belt"** can be implemented at a more economical and manageable pace. The responsibility of a "Yellow Belt" and "White Belt" is fundamental and there is an obvious overlapping role with individual day-to-day jobs. This abbreviated method of "Yellow Belt" and "White Belt" is project team members trained in the use of basic Six Sigma tools, but with much less training than either green or black belt. This addresses many constraints of the companies especially SMEs as a good "feel and taste" of Six

Sigma implementation to full-commitment [69]. It is important to choose a "right candidate" for the position of YB and WB. One needs to be regarded as "highly potential" and has the ability to hone Six Sigma into the company's day-to-day operations in return for company to measure benefits from Six Sigma implementation in dollars and cents.

Table 15 Responsibility of Six Sigma Belt Hierarchy System

Six Sigma Player	Responsibility
Champion	• He/She is a company representative who cannot be neglected in the Six Sigma team. He/She facilitates the implementation and deployment of the Six Sigma program [69]. • He/She is the upper level managers, leading the deployment of Six Sigma. Champions create the vision, define the path to Six Sigma quality, measures the progress and sustains business improvement [47, 69] • Every company requires the existence of champion to be part of the Six Sigma team for successful Six Sigma implementation [75]
Master Black Belt (MBB)	• MBB oversees several black belts and whose authority and influence often spans a large segment in most complex organizations. MBB is a "mentor" who develops a Six Sigma network, provides training on strategies and tools, gives one-to-one support on utilization and dissemination of Six Sigma tools and supervises the Six Sigma projects [50, 75] • MBB understands statistical methods involved and possess the highest level of technical and organizational skill within the organization [47, 69]. • MBB is qualified to teach other facilitators the methodologies, tools and application in all functions and levels of organization. He/She facilitates sharing of best practices and actively participates in the change process [47, 69]
Black Belt (BB)	• BB is a full time team leader job. Normally, it requires a minimum of 160 hours of training [47, 69] • BB is responsible in identifying and understanding business and operation processes in detail, and also understanding the levels of quality (especially tolerance of variation) that customers (internal and external) expect. This allows BB to measure the effectiveness and efficiency of each process performance against the variation encountered during the implementation [74] • BB is responsible for implementing process improvement for concurrent projects and is required to understand how Six Sigma strategies and tactics fits into larger management systems • He/She must be able to apply simple advance tools to solve and to prevent process problem. He/She must span an additional role as a Project Manager with best process improvement tools on DMAIC approach [47, 69] • BB reports the progress of their project to Master Black Belt and BB are expected to complete five Six Sigma projects prior to gaining the certification [50, 75]
Green Belt (GB)	• There is an increasing number of organizations that have begun to require completion of the Green Belt within a designated period of time as a condition of continued employment [50, 75] • GB applies Six Sigma structured problem-solving approach under the direction of one or more skilled and more experienced Black-Belt. GB is responsible in forming and facilitating teams and managing projects from concept through to completion [47, 69] • GB works closely with BB but only spend a portion of time completing projects while maintaining their regular work roles. • GB usually involves five days of classroom work training and GB reports progress of their projects to BB. GB are expected to complete two Six Sigma projects upon certification [50, 75]
Yellow Belt (YB)	• YB is project team member with basic understanding on how to use and apply Six Sigma tools and normally requires one day training [175] • YB receives introductory training to process management and the basic tools of Six Sigma to provide meaningful assistance in achieving an organization's overall objectives
White Belt (WB)	• WB is required to attend four hours of training where an overview of the history, philosophies, techniques and tools of Six Sigma will be introduced [176]. • WB benefits the managers whom are concerned with the status quo and interested in investigating options for productivity improvement, performance enhancement and organizational change. It is a good starting point for any organization to gain the "Six Sigma feel" prior to investing resources and money into Six Sigma methodology.

Source: Research analysis compilation

Figure 6 shows an overall view of a Six Sigma hierarchy system for SME companies [177]. Although it is ideal to acquire a certain number of black-belts prior to Six Sigma implementation, there are cases of SME companies which have successfully implemented Six Sigma with less focus on individual expert training and does not require dedicated Black Belts as illustrated by Markarian [177] in the following Six Sigma hierarchy system. This system introduces Green Belts (in replacement of Black Belt) into the picture of Six Sigma project where the project's success is dependent on the capability, experience and dedication of the "high-po (highly potential)" personnel and not being assessed by total number of training hours attended.

Source: Research analysis compilation

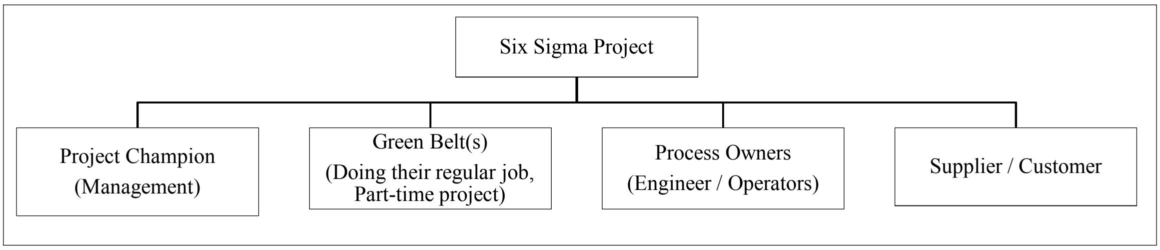


Figure 6 Six Sigma Hierarchy System for SMEs

3.2 Concept and Logic of Six Sigma

3.2.1 Introduction to Six Sigma Concept

Six Sigma has literal, conceptual, and practical definitions. At Motorola University (Motorola's Six Sigma training and consultancy division), Six Sigma functions at three different levels: (1) As a metric; (2) As a methodology; and (3) As a management system and approach. Essentially, Six Sigma is all three at the same time. From the point of view of Six Sigma as a Metric:

- The term "**Sigma**" is often used as a scale for levels of 'goodness' or quality. By using this scale, 'Six Sigma' equates to 3.4 defects per one million opportunities (DPMO) [69]
- **"Sigma"** represents a standard deviation indicating how tightly all the various samples and observations are clustered around a mean in a set of data points [69]
- **Sigma, σ** number is an indication of the amount of process variation [36]

3.2.2 Logic of Six Sigma

Sigma "σ" is a measure indicating the deviation on the performance characteristic of a service, product and process from the mean performance. Its' goal is to reduce variation within the tolerance or specification limits of a service performance characteristics. In order to achieve Six Sigma quality levels, one has to eliminate the causes of quality in process related problems before they are transformed into defects. Below are two examples (Table 16) used to elaborate the logic of Six Sigma in the Service industry:

Table 16 Illustration of Six Sigma Logic in the Service Industry [14]

Insurance Related Service Activities	Example: The time taken to process an insurance claim (Y), desired is not more than a specification limit (SL_{upper}) or upper specification limit. If the distance between process mean and the Specification limit is about six standard deviations, the process is said to be achieving "Six Sigma" quality level. If the process's drift factor is taken into account due to various sources of external uncontrollable influences (fluctuation of emotional conditions of staff members) over a period of time, then the defect rate is about 3.4 parts per million
Call Center	Take into consideration of a call or contact center, the following are opportunities which might lead to defects, which ultimately causes customer dissatisfaction and hence loss of customer: • The manner in which the customer is greeted by the customer service agent or customer service representative • The accuracy of information provided by the agent to the customer • The queuing time before the customer gets hold of an available agent • The number of rings before an agent responds to the call • The accuracy of the data entry of customer identity to retrieve past data • The listening, speaking and interpretive skills of the agent etc.

Source: Research analysis compilation

3.2.3 Sigma Level Determination

It is common to say that many **ordinary businesses** actually operate at **between two sigma and three sigma performance**. This equates to between approximately 66,800 and 308,500 defects per million opportunities, (which incidentally is also generally considered to be an unsustainable level of customer satisfaction where the business is likely to be in-decline, or about to head that way) [74]. Other authors like Benes reviewed that most companies operate at 3-sigma (67,000 DPMO) or 4-sigma (6,200 DPMO) [69]. Whatever it is, the focus of Six Sigma is NOT counting the defects in the process, but the number of opportunities within a process that could result in defects. The one-to-sigma conversion table with statistical comparison of Six Sigma definition is illustrated in Table 17.

Table 17 One-to-Sigma Conversion Table : Statistical comparison of Six Sigma Definition

The Definition of Statistics [110]			**The Definition of Six Sigma** [36, 70, 74, 110]		
Specification Limit	Percent	Defective (PMO)	Specification Limit	% of successful outputs or operations	Defects Per Million Opportunities (DPMO)
± 1σ	68.27	317,300.00	± 1σ	≈30.23	≈697,700
± 2σ	95.45	45,500.00	± 2σ	≈69.13	≈308,700
± 3σ	99.73	2700.00	± 3σ	≈93.32	≈66,800
± 4σ	99.9937	83.00	± 4σ	≈99.3790	≈6,210
± 5σ	99.999943	0.57	± 5σ	≈99.97670	≈233
± 6σ	99.9999998	0.02	± 6σ	≈99.999660	≈3.4

Source: Research analysis compilation

3.2.4 Six Sigma Calculation

The common definition for defect, unit and opportunity as well as Sigma level determination for different product, service and process is discussed in this section. The "**D**efects **P**er **M**illion **O**pportunities (DPMO)" measures the number of defects in a process, service and product in terms of a million opportunities. It can be evaluated by the following equation [135]:

$$DPMO = \frac{\text{Number of deffects}}{Number\ of\ opportunities} \times 10^6$$

Prior to calculating the sigma level, one needs to define the "defect", "unit" and "opportunity". Once these metrics are defined, the calculation of sigma level is straightforward. By norm, a variation of ± 1.5 sigma for software processes is not a surprise. Table 18 is the illustration of Six Sigma calculation using Call Center Helpdesk services as an example discussed by Hong & Goh [36]:

Table 18 Examples Illustration of Six Sigma Calculation [36]

Details	**Services**		**Process**		**Product**	
Description	Call center helpdesk	Electronic telephone book software (source code)	Electronic telephone book software (source code)	Electronic telephone book software (source code)	Electronic telephone book software (source code)	Electronic telephone book software (source code)
Defect	Calls with hold time ≥ 2 minutes	FPs causing customer dissatisfaction	Entries incorrect	Keystrokes anomaly	Lines causing compiling / execution failure	Each execution (per run)
Unit	Each call	Each FP*	Each phone entry	Each keystroke	Each line of non-commented source code (LOC**)	Failures upon execution
Opportunities for error per unit	1 per call	1 per FP	5 per entry	1 per keystroke	1 per LOC	1 per run
No. of defects	205 calls	1 per FP	36 entries	65 keystrokes	8 LOCs	3 failures
No of Unit	36,583 calls	6,807 FPs	1,050 times	82,268 keystrokes	12,560 LOCs	6,807

Details	Services		Process		Product	
DPMO	$= \frac{205}{35,583} \times 10^6$ = 5,604	$= \frac{3}{6,807} \times 10^6$ = 441	$= \left\{\left\{\frac{36}{1,050}\right\} / 5\right\} \times 10^6$ = 6,857	$= \frac{65}{82,268} \times 10^6$ = 781	$= \frac{8}{12,560} \times 10^6$ = 637	$= \frac{3}{6,807} \times 10^6$ = 441
Sigma Level	4.04σ	4.826σ	3.965σ	4.663σ	4.772σ	4.826σ
Note : To calculate the sigma level for software correctly, defect and opportunity for defect should have a one-to-one relationship. This means that one defect should correspond to one opportunity for defect. It is worth nothing that software defects are often of the logical type; in some cases, one failure leads to modification of source code in several different places, and this will lead to different sigma levels using different definitions. One should be very cautious about the definition when referring to sigma levels. ***FP** – Function Point ****LOC** – Line of Code						

Source: Research analysis compilation

3.3 Six Sigma Methodology

3.3.1 Six Sigma DMAIC

Six Sigma concepts are models based on the model concepts of Total Quality Management (TQM) and Plan-Do-Check-Act (PDCA) [29]. Authors like Tonini et al., [29] is confident that Six Sigma can be applied to any businesses, because there is always a chance of improving the product, process and service, making it cheaper, better quality and offering it quicker to the market.

Six Sigma, being a problem solving methodology or process improvement framework, its' strategy makes use of a series of well-defined steps. Though the **Six Sigma DMAIC** (**D**efine**, M**easure**, A**nalyze**, I**mprove**, C**ontrol) framework is widely adopted and implemented in the past decades, effort of in-depth analysis at each phase is required to ensure root-causes are identified and analyzed, especially during the initial stage. **DMAIC** is a highly data-driven, fact-based application of the scientific method of inquiry that emphasizes discernment and implementation of the so-called VOC (as related to processes, products and services) that creates value for the products and the consumers [50].

The five phases DMAIC methodology uses a collection of tools and techniques, acting as logic filter to lead the team to the vital few factors affecting process outcomes [75]: (1) **D**efine opportunity ; (2) **M**easure performance ; (3) **A**nalyze opportunity ; (4) **I**mprove performance ; (5) **C**ontrol performance ; (6) **T**ransfer idea/knowledge [11, 74] **OR** (7) **R**eporting [49]. Therefore, it is important for the team to follow a set of guidelines on each stage of the DMAIC process to ensure resources are maximized to the fullest. Table 19 summarized the collective activities, process and tools and techniques description at each stage of the DMAIC process from literature reviews.

3.3.2 Six Sigma DMADV– Design For Six Sigma (DFSS)

Confusion always arises between the term of DMAIC and DMADV. Many readers are in doubt if DMAIC and DMADV are interchangeable? Can both the methodologies be used at the same time? Which method is the best in any "situation"? **Six Sigma DMAIC** is a quality methodology used when a process/product/service is in existence at your company but not meeting customer specification or it is not performing adequately. It aims to “root out and eliminate the causes of defects” and its’ purpose is to affect real change to the existing problematic process to achieve organizational mission and vision. DMAIC can be utilized to fix under-performing processes [65]. DMAIC is a methodology used for **existing processes** and carried out by trained professionals in the form of Black Belts, Green Belts and overseen by Master Black Belts.

While Six Sigma process improvement approaches leaves the fundamental structure of a process unchanged, **DFSS** (**D**esign **F**or **Six Sigma**) involves changing or redesigning the process at the early stage of process/product/service life cycle [11]. **DMADV** (**D**efine, **M**easure, **A**nalyze, **D**esign, **V**alidate) is the acronym for **Design for Six Sigma**. It was developed by Thomas Pyzdekis and is a DMAIC variation that has been applied to develop new products [29]. When activities are unique (specific projects), there is NO way of improving or controlling, DMAIC improvement and control stages were substituted by the design and verification stages. The objective of DMADV is to ensure repetition and continuous improvement [60].

As reviewed by Chan et al., Benes and Goncalves et al., **DFSS uses DMADV to design new processes/products/services** in order to design and to move the “new products or services” to market [60, 65, 69]. DFSS can be used to optimize an “**existing** products or processes or services” which fail to meet “customer specification or Six Sigma level”. Following are some examples of situations where DFSS indeed become mandate and necessary:

- The current process has to be replaced, rather than repaired or just improved
- The required quality level cannot be achieved by just improving an existing process
- An opportunity is identified to offer new process
- Breakthrough and new disruptive technologies.

DFSS is the solution to design products, processes and services in a cost-effective and simple manner. It has significant impact in long term profitability where it increases customer satisfaction and market share. It is important to note that DFSS is **NOT** a replacement for new product introduction process but it is a methodology to make a new product, process and service introduction more efficient, reliable and capable of meeting customer expectations and requirements. In short, the DFSS approach is an inventive way to satisfy and exceed the customer requirements.

Table 19 Activities, Process and Tools and Techniques Description at each stage of DMAIC Process

Phase	Activity/Process Description	Tools	Ref
Define	• To define the scope and objective of the project, the CTQs issues, VOC, the potential improvement opportunities, and important quality measures and expectation [11], [36] • Top management require to define Six Sigma goals and to estimate the financial benefits through customers' and other users' feedback [110]	Project charter	[11, 115, 135]
		Project Evaluation	[115]
		CTQ Characteristics	[115]
		Benchmarking surveys	[11]
		Spider Charts	[11]
		Flowcharts	[11]
		SWFMEA	[115]
		SWQFD	[115]
		Kano Analysis	[115]
		Process Map	[115]
		Affinity Diagram	[115]
		SIPOC Diagram	[135]
Measure	• To define what constitute a defect, an opportunity and the measurement unit for Six Sigma calculations [36] • To measure the process performance, especially the CTQs, to analyze the operations of the current system, measure and determine current performance, and to quantify the problem [11], [36] • A suitable measuring system should be developed, correct gauging method should be used, goals should set up according to the customers and users demand [110]	Quality Function Deployment (QFD)	[11]
		Failure Mode, Effect, Critically Analysis (FMECA)	[11]
		Gage R&R	[11, 115]
		Process Capability Analysis	[115]
		Process Yield Analysis	[115]
Analyze	• To analyze collected data and use process maps to determine root causes of defects, and to prioritize opportunities for improvement. Apply statistical tools to guide and validate the analysis whenever is required [11], [36] • To design a case procedure to find out any variation and bottlenecks in the process/product/service [110]	Histogram / Pareto Chart / Run Chart / Line Chart	[11, 115]
		Scatter Plot / Cause and Effect Diagram	[11, 115]
		Product Capability Analysis	[11]
		Failure Mode, Effect, Critically Analysis (FMECA) or Health FMEA	[11, 135]
		Correlation Analysis	[115]
		Regression Analysis	[115]
		Two Sample t-test	[115]
		ANOVA	[115]
		Earned Value Analysis (EVA)	[115]
		Gap Analysis	[135]
Improve	• To improve the process by designing creative solutions to fix and prevent problems. Some experiments may be performed in order to find the best solution. Optimization methods are utilize to determine the optimum solution [11] • To have check points to ensure the desired result are being achieved and the propose solutions to analyze process/product/service are effective and efficient [110], [36]	Quality Function Deployment (QFD)	[11]
		Statistical Experimental Design and Analysis Simulation	[11]
		Design of Experiment (DoE)	[36]
		Cause and Effect Diagram	[115]
		SWFMEA	[115]
		Cost Benefit Analysis	[115]
Control	• To define and validate monitoring and controlling mechanism, develop standards and procedures, verify benefits, cost savings and lessons learned [36] • To control the process on the new course. It is necessary to have performance tracking mechanisms, and measurements are put in place to assure that the gains are not lost over time. The key to the overall success of Six Sigma methodology is its sustainability [11] • To ensure the propose procedure is under control after the launch of improvement program [110]	Gage R&R	[115]
		Statistical Process Control / Control Charts	[11, 115]
		QS9000 / ISO9000	[11, 115]
		SWFMEA	[115]
		Project Assessment	[115]
		Project Summary	[115]
Transfer	• To transfer ideas, method, solutions and knowledge developed in one project to other sections of the organization. The aim is to reduce time taken to learning curve during project start-up phase [11]	Project Management	[11]
		Collaborative team effort and cross functional teams	[11]
Report	• To report the benefits of the re-engineered process to the top management so that cost-and-benefits analysis can be benchmarked for next potential project [49].		

Source: Research analysis compilation

3.3.3 Six Sigma Roadmap (SSR)

SSR was developed by Pande et al., in 2001 [152]. It allows Six Sigma adoption through three strategies, i.e. "Individual or concomitantly used", "current process improvement" and "process reengineering and process management". It is quite a complete method which includes Six Sigma implementation and management with five stages of processes:

- Identification of the main customer-key processes, which allow creation of a customer vs. process table
- Customer needs definition through direct customer research (VOC), benchmarks establishment, requirements description to analyze and prioritize business needs and strategies;
- Current performance measurement, to know the current process capacity and the defective points;
- Prioritizing, analyzing and implementation of improvements, in a way that maximizes returns;
- System expansion and integration, through actions to maintain improvements, define responsibilities and control improvement process.

The author is adopting "The Roadmap and Tools of Six Sigma" by Pande et al., [152] for the research case companies. A detail illustration of "The Six Sigma Way" was discussed with examples illustration from different IT (IT Processes, IT Services and IT Products) and non-IT case studies. The map making approach of "The Six Sigma Way" by Pande et al., formed a basic idea of "how-to" of Six Sigma major components and tools for establishing the Six Sigma system and launching improvements. The roadmap proposed by Pande et al., is not the only path to Six Sigma improvement; adjustment of the order of the steps is allowed, starting more than one step simultaneously when necessary, add-on activities/tasks as needed depending on business environment and business nature. This roadmap only serves as a foundation framework in supporting and sustaining Six Sigma improvement. The advantages of this roadmap are:

- A clearer understanding of the business as an interconnected system of processes and customers.
- Better decisions and uses of resources, to get the greatest possible amount of benefits out of Six Sigma improvements.
- Shorter improvement cycle times, thanks to better upfront data and selection of projects.
- More accurate validation of Six Sigma gains – whether in dollars, defects, customer satisfaction, or other measures.
- A stronger infrastructure, to support change and sustain results.

3.4 The Six Sigma Roadmap – Case Study Approach

The author initiated process improvements at case study companies using "The Six Sigma Way". The Six Sigma way refers to a five-phase improvement cycle of **D**efine, **M**easure, **A**nalyze, **I**mprove and **C**ontrol or **DMAIC**. This study will be using DMAIC to apply appropriate Process Improvement and Process Design/Redesign efforts in the case companies. The DMAIC model from Pande et al., [152] are adopted and Table 20 is an overview of Process Improvement and Process Design/Redesign in the DMAIC model. The five-steps of Six Sigma Roadmap featuring the "core competencies" for a successful 21st century organization according to the "The Six Sigma Ways" are shown in Figure 7.

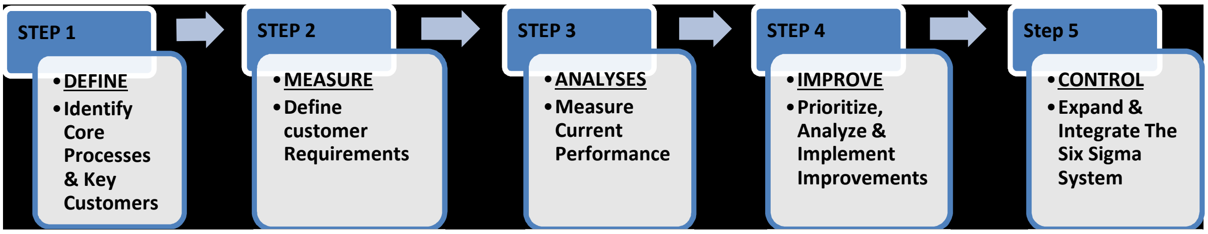


Figure 7 The Six Sigma Roadmap [152]

Table 20 Overview of Process Improvement and Process Design/Redesign "path" in DMAIC model [152]

	Six Sigma Improvement Process	
	Process Improvement	**Process Design / Redesign**
1. **Define**	• Identify the problem • Define requirement • Set Goal	• Identify specific or broad problems • Define goals and change vision • Clarify scope & customer requirements
2. **Measure**	• Validate problem and process • Refine problem and goal • Measure key steps and key inputs	• Measure performance to requirements • Gather process efficiency data
3. **Analyze**	• Develop casual hypotheses • Identify "vital few" root causes • Validate hypothesis	• Identify "best practices" • Assess process design: (1) Value and non-value adding ; (2) Bottlenecks and disconnects ; (3) Alternate paths • Refine requirement
4. **Improve**	• Develop ideas to remove root causes • Test solutions • Standardize solution and measure results	• Define new process: (1) Challenge assumptions ; (2) Apply creativity ; (3) Workflow principles • Implement new process, structure, systems
5. **Control**	• Establish standards measures to maintain performance • Correct problems as needed	• Establish measures & reviews to maintain performance • Correct problems as needed

3.4.1 Step-1: Identify Core Process, Support Processes and Key customers

As IT businesses become more dispersed, global and unpredictable, customer segments more narrow, products and services more diverse, it gets tougher and more challenging to see the "big picture" of how the work actually gets implemented [152]. By kick-starting with step-1, the big picture of the current "investigation" will be brought into clearer focus by defining critical activities and most importantly getting a broad overview structure of the business system or a new, clearer understanding gained about the organization as a whole.

3.4.2 Step-2: Define Customer Requirement

It has always been a challenge of the Six Sigma approach in getting good customer input regarding a company's needs and requirements. One should put oneself into customers' shoes to know what customers want, this is the only way of developing meaningful measures in order for the team obtain clear and specific requirements. The team needs to ensure data gathering covers all areas; not limiting to one area only and entirely ignoring other areas. The aim is to really listen to customers (especially seeing them in long-term survival and success). The suggested tasks the team must undertake to develop the deliverables in step-2 are:

- Gather customer data, develop a "Voice of the Customer" strategy
- Develop performance standards & requirements statements
- Analyze & prioritize requirements; evaluate per business strategy

3.4.2.1 Identify Critical-To-Quality

It is vital to understand the unique aspects of service processes and identify opportunities for improvement and set up effective measures of performance before launching Six Sigma projects [178]. Many companies often overlook the CTQs' measurement indicators and results in quality management are not adequately addressed [107]. When the measurement system analysis for CTQs is too generally defined, there is very little room for significant improvement in sigma level. Indirectly, more pressures are accumulated to the following DMAIC processes where it may be vulnerable to implementation failure.

Critical-To-Quality (CTQs) are the key measurable indicators of a product or service whose performance standards or specification limits must be met in order to satisfy the customer. CTQs align improvement or design efforts with customer requirements and they are the spoken needs of the customer. In layman terms, CTQs are what a customer expects of a product or service [32]. The common CTQs across services are service time, waiting time and cycle time [32]. In the event where the customer himself/herself involves in the process, time is an important factor in determining customer satisfaction level.

3.4.2.2 Identify Voice-Of-Customer

It is critical to ensure company's core processes are aligned to the CTQs and to find customers' needs through surveys, call center data, focus groups, promotional campaigns etc. The objective is to align **Voice-Of-Customer (VOC)** with key business issues. Companies require understanding of customer requirements and fulfilling them by ensuring company processes' effectiveness and efficiency (e.g. high rate of defects, time and money waste in non-value added activities increases cost-per-transaction) [118]. It is advisable to start with processes that are self-contained within a unit or process that does not rely on a change in another process [14, 89]. Furthermore, it is necessary to prioritize improvement projects according to what is the most critical to the company such as customer service, time, money, perceived value etc.

It is often difficult to identify problems in the Define phase [69]. It requires experience and knowledge to take on this task. What worsens the situation is when the problem related to CTQ may be ill-defined or maybe hard-to-define; that will caused difficulty in defining and decomposing the problem and its' situation [69]. One way is to carry out a simple mapping of the processes from both directions (up-stream and down-stream) to determine where the problems lie [15]. The most challenging part in applying Six Sigma in service industries is to identify the appropriate CTQs which are highly intangible and behavioral oriented because they are difficult to quantify [179].

3.4.3 Step-3: Measure Current Performance

While step-1 and step-2 identify the preliminary investigation and understanding on general overview and gathering requirements; the knowledge-building and information-building gained from these stage is important as a prerequisite baseline to see how well the company delivering these requirements today and how likely it would be in the future.

On a broader level, the measurement systems should capture data on performance measures as well as process efficiency (e.g. cost per output, rework, material, resource consumption etc.). The major tasks in this measurement steps are: (1) Plan & execute measures of performance against customer requirements; (2) Develop baseline defect measures & identify improvement opportunities.

3.4.4 Step-4: Prioritize, analyze and Implement Improvements

Once the team was equipped with facts and measures, next step is to perform business process improvements. It is important to choose improvement priorities carefully and not to "overload" the organization with more activities than it can handle. Six Sigma Tools and Techniques have the capability to be applied to large, complex business problems as well as to fairly simple Process Improvement opportunities. While selecting improvement projects and develop project rational, there are two approaches the team can adopt:

- Incremental Change – Analyze, develop and implement root cause-focused solution(s). The DMAIC cycle in this approach is not purely a linear activity. As any team begins probing, gathering and measuring data etc., the team almost invariably makes discoveries about the problems and process. The improvement process is an iterative activity where suggestions and actions plan can be revised even up to the point of implementation solutions.
- Variations for design/redesign – Design/redesign and implement effective new work process. In order to achieve Six Sigma levels of performance and keep pace with market and technology changes, both Six Sigma improvement strategies and design/redesign will be needed. This way of "reinventing" activity focused on exponential versus incremental improvement.

3.4.5 Step-5: Expand and Integrate the Six Sigma System

Six Sigma is not a quick fix and the real "Six Sigma performance" can be achieved only through a long-term commitment to the core themes and methods of Six Sigma. This is the stage the project team should explore both the short and long term challenges of sustaining Six Sigma improvement and building all the concepts and methods of step 1-4 into an ongoing, cross-functional management approach. The key actions in managing processes for Six Sigma Performance are:

- Implement ongoing measures and actions to sustain improvement
- Define responsibility for process ownership and management

- Execute "closed-loop" management and drive to Six Sigma

The summary of "The Six Sigma Roadmap" is tabulated in Table 21 outlining the objective and deliverables for respective DMAIC phase.

Table 21 The Roadmap of Six Sigma - Step Overview [152]

Step	Phase	The Roadmap of Six Sigma	Objectives	Deliverables
1	Define	Identify Core Processes & Key Customers	To create a clear, "big-picture" understanding of the most critical cross-functional activities in your organization, and of how they interface with external customers.	A "map" or inventory of value-delivering activities in your organization, driven by three questions: • What are our cores or value-adding processes? • What are the products and services provide to customers? • How do processes "flow" across the organization?
2	Measure	Define customer Requirements	• To establish standards for performance that are based on actual customer input, so that process effectiveness and capability can be accurately measured – and customer satisfaction predicted • To develop or enhance systems and strategies devoted to ongoing "voice of the Customer" data gathering.	A clear, complete description of the factors that drive customer satisfaction for each output and process – aka "requirements" or "specifications" in two key categories: • 'Output Requirements" tried to the end product or service that make it work for the customer (what quality gurus have called "fitness for use") • "Service Requirements" describing how the organization should interact with the customer
3	Analyze	Measure Current Performance	To accurately evaluate each process's performance against definable customer requirements, and to establish a system for measuring key outputs and service features.	• Baseline Measures – quantified evaluations of current and recent process performance • Capability Measures – assessment of the ability of the current process and output to deliver on requirements. These include "Sigma" scores for each process that allow comparison of very different processes • Measurement Systems – new or enhanced methods and resources for on-going measurement against customer-focused performance standards.
4	Improve	Prioritize, Analyze & Implement Improvements	To identify high-potential improvement opportunities and develop process-oriented solutions supported by factual analysis and creative thinking, also, to effectively implement new solutions and processes and provide measurable, sustainable gains.	• Improvement Priorities. Potential Six Sigma projects assessed based on their impact and feasibility • Process Improvements. Solutions targeted to specific root causes (aka "continuous" or "incremental" improvements). • New or Redesigned Processes. New activities or workflows created to meet new demands, incorporate new technologies, or achieve dramatic increases in speed, accuracy, cost performance etc.
5	Control	Expand & Integrate The Six Sigma System	To initiate ongoing business practices that drive improved performance and ensure constant measurement, reexamination, and renewal of products, services, processes, and procedures. This is the step where the organization works hard to achieve the vision of a Six Sigma.	• Process Control. Measures and monitoring, to sustain performance improvement. • Process Ownership and Management. Cross-functional oversight of support processes with input from Voice of Customer, Voice of Market, Voice of Employee, and process measurement systems. • Response plans. Mechanisms to act based on key information so as to adapt strategies, products, services and processes. • Six Sigma "Culture". An organization positioned for continuous renewal, with Six Sigma themes and tools an essential part of the everyday business environment

3.5 Six Sigma Tools and Techniques

There are various classification schemes for Six Sigma Tools and Techniques. The tools involved in the DFSS methodology are somewhat different from those of the DMAIC methodology. DFSS includes innovation tools such as the theory of inventive problem solving, axiomatic design and quality function deployment, which DMAIC does not.

A pilot survey of Six Sigma in UK Service Organization has been carried out by Antony which outlines the most and the least commonly used tools and techniques [107]. Two hundred well-designed questionnaires were sent to service organizations in the UK (from FAME database) with response rate of 14% (i.e. 28 companies). Only data from 23 companies were useful for the analysis. Data were collected and compiled; the result from the pilot survey highlighted the following:

- Most commonly used tools and techniques are brainstorming ; process mapping ; affinity diagrams ; root cause analysis ; control charts ; benchmarking ; Pareto analysis ; change management tools
- Least commonly used tools and techniques are quality function deployment ; hoshin-kanri (policy deployment) ; kano model ; design of experiment ; statistical process control ; poka-yoke (mistake proofing)

3.5.1 Category of Six Sigma Tools and Techniques

Most published articles are focused in introducing and discussing “Six Sigma Tools and Techniques” as an independent topic, rather than relating it to the overview of project life cycle (PLC) and System Development Life Cycle (SDLC). This is a crucial discussion topic to gauge both the PLC and SDLC with Six Sigma Tools and Techniques to provide a holistic view on how Six Sigma tools and techniques fit into different stages of PLC and SDLC. Knowing “what are” Six Sigma tools and techniques does not benefit an organization, a project manager or project champion who is well-versed in utilizing the right tool and technique at the right time using the right resources under the right project conditions could lead to successful implementation of Six Sigma projects. Hence, it is a “must” task or responsibility to evaluate the project’s condition prior to applying any tools or techniques [73]. Table 22 shows a reviewed list of Six Sigma category of tools and techniques applicable in various activities in PLC and SDLC. Six Sigma cannot be implemented in vacuum and multiple tools and techniques are needed in supporting the day-to-day project activities [65]. These categories of Six Sigma tools-mapping allow one to actively and effectively manage and monitor the project.

Table 22 Category of Six Sigma Tool [108]

Category	Tools and Techniques	
Gathering Ideas and Organizing Information	• Brainstorming • Affinity Diagramming • Cause and Effect (Fish Bone) Diagram • Tree Diagram	• High-Level Process Map • Flow Chart (Process Map) • Multi-voting
Data Gathering	• Sampling • Operational Definitions	• Voice of the Customer Methods • Check sheets and Spreadsheets
Process and Data Analysis	• Process Flow Analysis • Pareto Charts • Histograms (Frequency Plot)	• Run (Trend Chart) • Scatter Plot (Correlation) Diagram
Statistical Analysis	• Test of Statistical Significance • Correlation and Regression • Design Experiments	
Implementation and Process Management	• Project Management Methods • Failure Modes and Effects Analysis (FMEA) • Stakeholder Analysis	• Force Field Diagram • Balance Score Cards and Process Dashboards • Process Documentation

3.5.2 Six Sigma Tools and Techniques with Examples Illustration

The **Seven Basic Tools of Quality** can help in the selection of appropriate statistical techniques for investigating the causes of anomalies detected during the SDLC. Talib et al., has identified check sheets, Pareto diagrams, histograms, flowcharts, scatter diagrams, control charts, and cause-and-effect diagrams (fishbone diagrams, Ishikawa diagram) as the seven basic tools of quality [180].

Table 23 Seven Basic Tools of Quality and Six Sigma Tools and Techniques in DMAIC Framework

Phase	Tools	Illustration by Example	Reference
Define	Project Charter		[11, 115]
	Project Evaluation		[115]
	CTQ Characteristics		[115]
	Benchmarking surveys		[11]
	Spider Charts		[11]
	* Flowcharts	Page 68	[11, 180]
	SWFMEA		[115]
	SWQFD		[115]
	Kano Analysis		[115]
	Process Map	Page 69	[115, 180]
	Affinity Diagram		[115]
	SIPOC		[49]
Measure	Quality Function Deployment (QFD)		[11]
	Failure Mode and Effect Analysis (FMEA)	Page 70	[11, 180]
	Gage R&R		[11, 115]
	Process Capability Analysis		[115]
	Process Yield Analysis / Input Process Variables	Page 69	[115, 180]
Analyze	* Histogram / * Pareto Chart / Run Chart / Line Chart	Page 68	[11, 115]
	* Scatter Plot / * Cause and Effect Diagram	Page 68	[11, 115, 180]
	Product Capability Analysis		[11]
	Brainstorming	Page 69	[11, 180]
	Correlation Analysis		[115]
	Regression Analysis		[115]
	Two Sample t-test		[115]
	ANOVA		[115]
	Earned Value Analysis (EVA)		[115]
	* Check Sheet	Page 68	[115, 180]
Improve	Quality Function Deployment (QFD)		[11]
	Statistical Experimental Design and Analysis		[11]
	Design of Experiment (DoE)		[36]
	Simulation		[11]
	* Cause and Effect Diagram / Fishbone Diagram	Page 69	[115, 180]
	Cost Benefit Analysis		[115]
Control	Gage R&R		[11]
	Statistical Process Control / * Control Charts	Page 68	[11, 115]
	QS9000 / ISO9000		[11, 115]
	Project Assessment / Project Summary		[115]
	Process Improvement	Page 70	[115, 180]
	Casual Analysis		[180]
Transfer	Project Management		[11]
	Collaborative team effort and cross functional teams		[11]

Generally, the Seven Basic Tools of Quality emphasize quality at the late stages of the SDLC, just before implementation. Checklist and control charts introduce tollgates at every stage of the project life cycle. It is recommended that the quality focus aims at every stage of the project due to the cost-of-correction at the late stages of the project cost 20-times more than the initial stage [30]. Hence, the vision of the Seven Basic Tools of Quality is to introduce them as tollgates from the very beginning of a PLC, in order to improve the chances of a successful outcome.

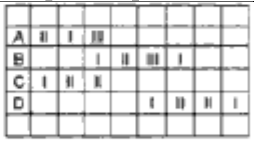
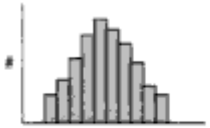
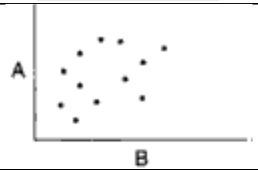
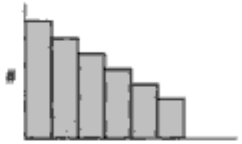
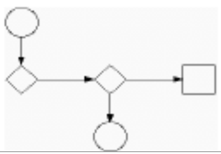
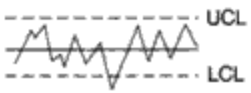
Table 23 outlines the Seven Basic Tools of Quality* and other Six Sigma tools in the stages of Six Sigma DMAIC process. Besides the Seven Basic Tools of Quality*; the tools and techniques (in gray) selection were extended to include “Process Map”, “Failure Mode and Effect Analysis”, “Input-Process Variables”, “Pareto Chart”, “Scatter Plot”, “Brainstorming”, “Check Sheet”, “Cause and Effect Diagram”, “Control Charts” and “Process Improvement” to close the gap of case study investigation covering every stage of DMAIC process. These selected tools were discussed and adopted by at least two or more case companies [11, 107, 115, 180] covering the entire Six Sigma cycle (i.e. DMAIC and DFSS). A mapping of tools and techniques (in gray) are selected for discussion in this study will be further discussed, illustrated and tabulated in Table 24.

3.6 Similarities and Differences of Six Sigma and other Methods of Implementation

TQM, Six Sigma, Lean and TOC are four different system improvement initiatives which are significantly distinct from one another particularly concerning the area of main theory, approach, criticism and others. Lean production philosophy and the Six Sigma quality steps are essentially the same and both have developed from the same origin as the management philosophy called TQM – namely Japan’s quality evolution [41]. The roadmaps of Lean production and Six Sigma quality are examples of new alternatives. The principles, concepts and tools of Lean production and Six Sigma quality should not be seen as alternatives to TQM but rather as a collection of concepts and tools, which support the overall principles and aims of TQM [41].

Besides the differences, practitioner Andersson et al. reviewed the similarities between TQM, Six Sigma and Lean. TQM, Six Sigma and Lean have many similarities, especially concerning origin, methodologies, tools and effects [40]. TQM, Lean and Six Sigma hold similar aims, i.e. “Through improvements minimizing waste and resources while improving customer satisfaction and financial results”. All these three improvement initiatives are essentially from the same origin, i.e. from the quality evolution in Japan (the Japanese TQM practices) after World War II but the concept was developed differently [41]. Table 25 summarizes the system improvement quality of Six Sigma, TQM, Lean and TOC.

Table 24 Six Sigma Tools and Techniques with Examples Illustration

Tools	Graphic Representation	Description	Example
Check Sheet * [180]		• Provide quick answer to a problem • Suitable for in-depth problem analysis and stratification • Can be applied throughout the SDLC • Types of check sheets : Tabular and Schematic • For complex issues, multiple entry ledgers are used (i)	N/A
Histogram * [180]		• A bar graph which shows frequency data • Evaluate various distribution of data : normal, bi-modal or multi-modal distribution, positively skewed or negatively skewed • Employed when there is a large number of data values • Independent variables versus frequency of dependent variables	N/A
Scatter Diagram * [180]		• Used to study the possible relationship between the changes observed in two different sets of variables • Two pieces of data are needed to create the diagram • Data pairs are plotted on the diagram and interpreted for direction and strength	N/A
Causes Pareto Diagram * [180]		• Used to identify problem and to prioritize problems • It is a histogram aided with 80/20 rule : approximately 80% of the problems are generated by approximately 20% of the causes • X-axis is usually the "defect cause" and the Y-axis is the "defect count" • Information is selected based on the types of defects, data are collected and classified into categories • When project starts, a series of refinements is applied to a set of requirements • Conducting a series of refinements where original specifications are compared with end-product for completeness and correctness	Example-1 • Used to identify fault-prone modules [180] Example-2 • Use in devising experiments in empirical decision making in design phase [180]
Flow Chart * [180]		• Used to plan and track software projects • First, break down an activity into a series of smaller manageable tasks to be organized sequentially or in parallel • Useful in facilitate planning and control of development processes	N/A
Control Chart * [68, 180]		• The collected data of the processes are represented along the horizontal axis • A medium line represents the average values; in other words, its normal condition • Used to determine whether or not a process will produce a product or a service with consistent measurable properties • Required to identify the critical operations in the process and the critical product characteristics • The upper and lower limits are set using statistical analyses • If actual data falls within the limits (normal distribution), the process is under control (statistically stable or predictable), else it will be out of control (unstable data distribution)	Example-1 • There is an increase interest in using control charts for monitoring and improving software processes like reviews and testing [180] Example-2 [68] • When establishing any goal, the process is capable if its results oscillate within a range delimited by upper and lower specification limits (LCL - low specification limit and UCL - upper specification limit, respectively). The narrower is the dimension (difference between upper specification limit and lower specification limit), the better the process is, because it presents smaller variation

<table>
<tr><th>Tools</th><th>Graphic Representation</th><th>Description</th><th>Example</th></tr>
<tr>
<td>Cause-and-Effect, or Fishbone Diagram * [180]</td>
<td></td>
<td>

Taking action on the root causes of a problem
“head” of the fish represents a problem
“bones” of the fish represents list of possible causes
Process performance was assessed to isolate key problem areas, to study the causes for the deviation from ideal performance and to identify if there is a relationship between the variables

</td>
<td>
<u>Example-1</u> [180]

“head” – software not achieving the required reliability
“bones” – list of causes related to the issue

<u>Example-2</u> [180]

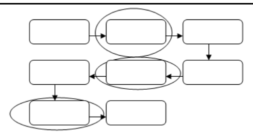
“head” - software not achieving the required reliability
“bones” – list of causes related to each of the steps in inspection process (overview, preparation, inspection, follow-up)

<u>Example-3 Risk and Hazard Analysis</u> [180]

“head” – risk and hazard of the problem
“bones” – potential drivers that cause the risk or hazard

<u>Example-4 Tata Consultancy Services</u> [181]

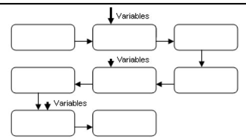
Due to a substantial number of projects were affected by poor-quality-of-inputs in 1998 (>50% of total number of projects are affected by Poor Input Quality), it was decided to analyze the effect of input quality separately. A Black-Belt project named “Analysis of Input Quality” was introduced to prevent defects occurring in the project deliverables due to wrong inputs
“head” – Non-Compliance Quality
“bones” – Initial study of packaging not done, Improper execution, No IQA, No casual analysis meeting, Poor quality of inputs, Lack of training, No EQA, Change in GE STDs, QA tool, Pipe master

</td>
</tr>
<tr>
<td>High-Level Process Mapping [181]</td>
<td></td>
<td>

It is a high-level process mapping of existing process/product/service
It started with identification of processes which are “critical to quality” (CTQ)
Normally involves team members from different levels

</td>
<td>
<u>Example-1 Tata Consultancy Services</u> [181]

In the Define phase, the project started with identification of Product Quality as the CTQ. The team members of Project Leaders, Team members and Quality Team were identified for the project.
It was identified that the key processes to CTQ are “Project Study”, “Execution” and “Delivery”

</td>
</tr>
<tr>
<td>Input-Process-Variables [181]</td>
<td>
</td>
<td>

In each of the identified processes, the input process variables (controllable or critical-those that show statistical significance) that affect the CTQ were identified
In the Measure phase, any attribute in the deliverable sent to the customer which does not meet the customer’s requirements, or which is not as per Customer’s Standards was defined as a defect. The opportunity, which is a product or process or service characteristic that is added-value or non-added-value will be defined by the client

</td>
<td>
<u>Example-1 Tata Consultancy Services</u> [181]

In the process of “Project Study”, “Execution” and “Delivery”, the Input Variable (Quality of Inputs), had various attributes namely, clarity of scope definitions, completeness of inputs, and conformance of inputs to standards.
This variable became a critical variable that affected the product quality, since the inputs for the projects were obtained from the customer. The projects that were affected by poor quality of inputs were measured

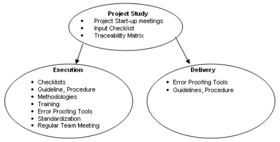
<table>
<tr><td>Process</td><td>Critical Variables</td><td>Controllable Variables</td></tr>
<tr><td>Project Study</td><td>Quality of Input</td><td>NIL</td></tr>
<tr><td>Execution</td><td>NIL</td><td>Product / Standard Knowledge
Tools</td></tr>
<tr><td>Delivery</td><td>NIL</td><td>Delivery Guidelines</td></tr>
</table>
</td>
</tr>
<tr>
<td>Brainstorming [181]</td>
<td>N/A</td>
<td>

N/A

</td>
<td>
<u>Example-1 Tata Consultancy Services</u> [181]

An extensive brain-storming session with team to evolve the probably causes in the Cause-and-effect diagram.
The probable causes that can lead to quality non-conformance in a project during different phases of a project life cycle were listed and further analyzed

</td>
</tr>
</table>

<table>
<tr><th>Tools</th><th>Graphic Representation</th><th>Description</th><th>Example</th></tr>
<tr>
<td>Process Improvement [181]</td>
<td>
</td>
<td>The aim of process improvements is the reduction of field errors
When the field errors reduced and the process capability for quality deliverables increased (improve in sigma level), the emphasis shifted to improvement of in-process quality. This is to be achieved through reduction of in-process quality cost</td>
<td><u>Example-1 Tata Consultancy Services</u> [181]
Based on the recommended actions from FMEA, several process improvement were introduced.
Process improvements such as “developing process control” and “error proofing tools” were among the improvement suggested to the processes of “Project Study”, “Execution” and “Delivery”
Customer Feedback form was introduced in this phase</td>
</tr>
<tr>
<td>Failure Modes and Effects Analysis (FMEA) [181]</td>
<td>N/A</td>
<td>FMEA was carried out to arrive at a plan for prevention of causes for failure.
It is a tool that helps prevent the occurrence of problem by:
Identifying the potential failure modes in which a process or product may fail to meet specifications, and rating the severity of the effect on the customer.
Providing an objective evaluation of the occurrence of causes
Determining the ability of the current system to detect when those causes or failure modes will occur.
Based on the factors, a Risk Priority Number (RPN) for each failure mode is calculated</td>
<td><u>Example-1 Tata Consultancy Services</u> [181]
For each identified potential failure mode, the potential causes, requirement of current controls, RPN and recommended actions were analyzed and discussed
<table>
<tr><th>Potential Failure Modes</th><th>Potential Causes</th><th>Current Controls</th><th>RPN</th><th>Recommended Action</th></tr>
<tr><td>Dispatch Incomplete</td><td>Work Pressure</td><td>No Control</td><td>200</td><td>Development of tools for complete delivery</td></tr>
<tr><td>PDM structure not followed</td><td>Lack of knowledge</td><td>No Control</td><td>180</td><td>PDM file handling procedure to be evolved</td></tr>
<tr><td>Non-conformance of Inputs with Standards</td><td>Information not given to all team members against blindly following SIMOTOs</td><td>No Control</td><td>160</td><td>Maintain a text file in pkg, directory, where a complete track of pkg, progress is recorded to address any deviations / non-conformance up front</td></tr>
<tr><td>Incomplete dispatch</td><td>Lack of knowledge</td><td>No Control</td><td>140</td><td>Process Procedure to include all the dispatch procedures</td></tr>
<tr><td>Non compliance to Standards</td><td>QA tool limitation</td><td>QA Tool</td><td>120</td><td>Limitations will be fixed by Jan’99 end</td></tr>
</table></td>
</tr>
</table>

Source: Research analysis compilation

Table 25 Differences of Six Sigma and other Methods of Implementation

Program	Six Sigma	Lean Thinking	TQM	Theory of Constraints
Acronyms [34, 40, 41, 46]	DMAIC / DMADV	Lean Manufacturing, Toyota Production Systems, Lean Production	-	-
Origin [34, 40, 46]	The quality evolution in Japan and Motorola	The quality evolution in Japan and Toyota	The quality evolution in Japan	-
Drive [37]	Stakeholder and capability driven	Shop-floor driven	Customer-driven	Process-driven
Theory [40, 41, 46, 49]	Reduce variation and defect	Reduce/Remove waste/ *"muda"*	Focus on customers	Manage constraints / Focus on system improvement
Aim [37, 41, 46, 47]	• Aims to understand how the input variables effect the output variables • Emphasis is on variation and waste reduction, capability development, best-in-class, employee fulfillment and cultural acceptance	• Concentrate on specifying what create values, identifying whole value stream (value-added act), making value adding activities flow, operating a "pull" system and striving for perfection • It removes non-value adding activities (i.e. over-production, defects, inappropriate processing, excessive transportation, waiting or unnecessary motion) • Difficult to transpose into profit statement as it does not have focus on driving direct cost out of an org	• To change corporate cultures from a passive and defensive culture to a pro-active and open culture. • Aim to increase customer satisfaction, continuous improvement and everybody's participations are applied everywhere in the organization • Emphasis is on outcome and quality is the means	TOC aims to produce positive effects on the flow time of the product or service through the system
Process View [37, 40, 46]	Reduce variation and improve processes	Improve flow in processes	Improve and uniform processes	The performance of the entire chain (system) is limited by the strength of the weakest link
Approach [40]	Project management	Project management	Let everybody be committed	Project Management
Methodologies [40, 46]	• Existing – DMAIC / DMAIC(R) • New DFSS - DMADV	1. Identify value 2. Identify value Stream 3. Flow 4. Pull 5. Perfection	Plan, Do, Study, Act (PDSA)	• Identify constraint • Exploit constraint • Subordinate processes • Evaluate constraint • Repeat cycle
Focus [37, 40, 46, 49]	• Problem focused • Data-driven • Statistical base • Detect errors and defects	• Flow focused • Does not confine itself to statistical approach • Detect or eliminate non-value-added activities	• Customer-focus • Data-driven • Tools have statistical based • Prevent errors and defects	Focus on the "process" that slows the speed of production
Tools and Techniques [34, 40, 73]	• Advanced statistical tools • Analytical tools • Supporting software • Represented a well contained packaged set of tools that can be used to measure and analyze manufacturing process variability and implement some form of process control	• By process and value analysis • Analytical Tools • Not about a tool, but rather culture that uses the right tool at the right time. Dealt with much more broader range of SPC (plethora). Should not only use Six Sigma tools to analyze and control a supply chain	• Analytical tools • Statistical tools • "Seven Quality Control Tools" • "Seven Management Tools"	-
Assumptions [46]	• A problem exists • Figures and numbers are valued • System output improves if variation in all	• Waste removal will improve business performance • Many small improvements are better than	-	• Emphasis on speed and volume • Uses existing systems (essential) • Process interdependence

Program	Six Sigma	Lean Thinking	TQM	Theory of Constraints
	processes is reduced	system analysis • People value the visual effect of flow • Process interaction effects will be resolved through value stream refinement		
Primary Effect [40, 46]	• Uniform process output • Save money	• Reduce flow time • Reduce lead time	• Increase customer satisfaction	Fast throughput
Secondary Effect [34, 40, 46]	• Less waste • Fast throughput • Less inventory • Fluctuation – performance measures for managers • Improve quality • Increase customer satisfaction • Achieve business goals • Improve financial performance	• Less variation • Uniform output • Less and reduce inventory • New accounting system • Flow – performance measure for managers • Improve quality • Increase productivity • Increase customer satisfaction	• Achieve customer loyalty • Improve performance	• Less inventory and less waste • Throughput cost accounting • Increase Throughput – performance measurement system • Improved quality
Criticism [40, 46]	• System interaction not considered • Processes improved independently • Does not involve everyone • Does not improve customer satisfaction • Does not have a system view • Does not in principle, contain anything new • Strong focus on result – data-driven	• Statistical of system analysis not valued • Reduces flexibility • Causes congestions in supply chain • Not applicable in all industry	• No tangible improvement • Resource-demanding • Unclear notion	• Minimal worker input • Data analysis not valued
Benefits [34, 49]	Highly effective in terms of delivering cost savings and, increased customer satisfaction	Contributed substantially to cutting costs and providing competitive advantages	Improving the competitiveness, effectiveness and flexibility of a whole organization	The effort can be localized with minimum involvement of the workforce
Branding [73]	With SPC as a basis proven to be a powerful and necessary tool for high quality manufacturing, it may be that the relative ease with which the Six Sigma tools can be packaged and taught, has led to its prevalence as a marketed "system" with educational institutions and consultant joining the bandwagon in the process because it is easy to teach.	Difficult as it includes so many TPS tools and techniques that it cannot be easily packaged into a consulting course or higher education course with discrete deterministic problems. TPS requires a set of 15 major Tools, including Six Sigma and major cultural realignment of the org to achieve to true Lean operating behaviors and outcomes.	-	-
Philosophy [73]	As a set of tools. Implemented in 1986 at Motorola and was seen as "a defect reduction tool, not the ultimate management philosophy".	As an operating philosophy. It has the presence of a "pattern of basic assumptions that a given group has invented, discovered, or developed in learning to cope with its problems of external adoption and integration, and that have worked well enough to be considered valid, and therefore to be taught to new members as the correct way to perceived, think and feel in relation to those problems"	-	-
Certification [73]	There is a spike of popularity since its creation in 1980's where there is an upward trend of interest in Six Sigma certifications. The demand for black belt certification has steadily increased since 2002	Does not offer certifications, it remains difficult to determine which industries have adopted these principles. It is more of a philosophy where the true number of users may never materialize	-	-
Comparative	-	TPS way of thinking includes controlling the	-	-

Program	Six Sigma	Lean Thinking	TQM	Theory of Constraints
Analysis [73]		variation, more importantly, a mindset of preventing the variation from ever occurring. Concentrate its effort on "problem solving" by attacking the actual source of the problem		
Easiness [49]	Tough to implement in terms of quantitative and qualitative goals	-	Easier to implement	-
Organization Culture [37, 68]	Cultural acceptance is emphasized, and multi-stage corporation is the approach	Continuous improvement is emphasized. Team work and work morale is the approach	Continuous improvement is emphasized and team work is the approach	-
Organization Structure [37, 68]	Emphasis is on system visibility; provide accurate and real-time information; the DMAIC cycle is emphasized	Horizontal approach; shop-floor activities is emphasized	Horizontal approach, provides real-time information: flexible ; the Deming cycle is emphasized	-
Cost and Duration [49]	• high to medium investment required (depends on project) • It takes long duration (3-9 months) to complete the project	-	• Usually moderate budget allocations made in lieu of higher gains • Project size are moderate	-
Cause of Failure [37]	Lack of statistical thinking, system thinking, strategic thinking and transition management	-	Common causes which result from the failure of top management to manage effectively	-

Source: Research analysis compilation

3.7 The Common Myths and Realities (Myths Demystified) of Six Sigma

Debates on Six Sigma emergence as a strategic initiative has caused certain critics to voice out that it is a case of "old wine in a new bottle" [41, 75]. On the other hand, Six Sigma is also being criticized as either a fad or just another quality initiative [48]. Six Sigma will continue to grow as a powerful management initiative for achieving and sustaining operational and service excellence [75]. However, what will eventually determine whether Six Sigma is viewed by businesses as just a passing management fad or not, largely depends on the leadership and success of its execution. The authors believe that organizations which develop and implement Six Sigma should not view it as an advertising banner for promotional purposes [75]. Table 27 summarizes the common myths and myths demystified of Six Sigma.

3.8 Kick Start Six Sigma

Following the detailed discussion on Six Sigma, it is useful to draw up a checklist and a list of important key ingredients for Six Sigma implementation. In order to kick start with Six Sigma improvement initiatives, Duncan suggested a set of rules where managers and staff should be under constant pressure to conceive and execute ways of improving business performance [18]:

- Firstly, the team should focus on cracking the really big issues because Six Sigma programmes are expensive to run and can be resource hungry, so it is important to make sure potential savings are high to start with.
- Next, train your best people, not those who happen to be available at the time. Prior to forming the Six Sigma team, it is necessary in getting board-level endorsement before undertaking any Six Sigma program. This is to ensure there is focus, resources and momentum needed to succeed. At the same time, the management team should clearly establish what constitutes a success at the outset in the company-wide level.

It is important to note that Six Sigma should take a balanced approach to quality management which focus on three factors of "Understanding customer requirement", "Reducing variation in process outcomes" and "Simplifying process (less complex process lead to less error)" [18]. It is without doubt that deploying Six Sigma will cost organizations some money and time, but it will be worth expanding that time, money and effort to achieve real measurable financial results. Organizations face a myriad of problems in their day-to-day functions. Six Sigma can be applied where there is a problem, irrespective of type or size of business [75].

3.8.1 The Key Ingredients For Six Sigma Implementation

Key ingredients are those factors that are essential to the success of the implementation of any quality improvement initiatives. The identification of such factors encouraged the management team's consideration when companies are developing an appropriate Six Sigma implementation plan. The key components of successful Six Sigma implementation are "upper management support", "efficient and effective organization infrastructure", "training", "application of statistical tools and link to HR-based actions" (e.g. bonuses, promotions etc.) [164].

Following is a summarized list of key ingredients (Table 26) review by Kuei & Madu [37] which serves as a basis when implementing a Six Sigma project:

Table 26 Key Ingredients for Six Sigma Implementation [37]

No	Key Ingredients
1	Management involvement and commitment (top down approach)
2	Adjustment to the culture of an organization and a change of employees' attitude
3	Effective and efficient organization infrastructure to support the introduction and development program
4	Sufficient training classes to improve employees' comfort level on what Six Sigma is
5	Project Management skills in dealing with deadlines and milestones
6	Establish project prioritization and selection criteria, reviews and tracking
7	Understanding the Six Sigma methodology, tools and techniques for greater breakthrough improvement in business processes
8	Necessary to linking Six Sigma to business strategy in order to make business processes profitable
9	Ability to link Six Sigma to customers to foster good understanding of user requirements
10	Linking Six Sigma to human resources as a means of individual behavior drivers (e.g. promotion for someone if attended and completed full Six Sigma training)
11	Encouraging the participation of suppliers to Six Sigma implementation as a way of obtaining support from the supplier firm

3.8.2 The Challenges of Six Sigma

Six Sigma has much to offer for businesses. However, the ability to utilize it successfully does require a degree of adoption to suit the sector, culture and specific project. A list of key challenges were reviewed by Duncan [18] with the aim to increase innovative ways to utilize Six Sigma programs and create improvement in business performance.

One of the critical challenges of implementing Six Sigma in the field of IT is the awareness of IT professionals and specialists seeing Six Sigma as a well-rounded QIM which outweigh other traditional QIM by placing great emphasis on post-operations evaluation. Six Sigma's approach of proactive and consistent data-driven methodology has started to drive public awareness of adopting Six Sigma as a quality management system. It is important for the warrior team to gauge a **common language** among the entire project team to avoid misunderstanding and miscommunication caused by a combination of literal interpretation (e.g. minimizing defects, minimize complaints, minimize downtime, improve productivity, eliminate non-value add activity etc.). Many businesses don't think in terms of minimizing defects, rather they talk about solving problems. When companies trying to get buy-in on Six Sigma implementation, it is important to ensure one explains the type of improvements that Six Sigma can achieve by couching terms in a way that the audience will recognize and identify with.

Any sorts of **changes in management style** may bring some degree of resistance and the buy-in process may take some time. So perseverance of support and endorsement from top management is important. It is important to ensure **training goes hand-in-hand with real project work** and never divorce the two entities. Nevertheless, the theory is important but there is nothing like a real project to bring home the challenges and benefits that a well-targeted and supported Six Sigma programme can bring. The best way to gain buy-in is through demonstration of values.

Besides, attention is needed to **focus on big issue** (company level) to maximize the gains in dollars and cents, which requires the effort from the team as well as the management.

3.9 Chapter Summary – Six Sigma, The Road Ahead

Software development is always in a dynamic environment. Implementing a Six Sigma programme does not mean forcing companies to achieve 3.4 DPMO line-of-code overnight. Instead, a roadmap should be laid out to increase the sigma level, plus the action plan to achieve or align with organizational goals. The roadmap should incorporate the technology changes to achieve the appropriate quality goals. More work is required to fully realize the potential benefits of Six Sigma. Six Sigma should be used in conjunction with a sigma roadmap and action plan at each revision point [36].

Many people have the fear that designing a Six Sigma quality level system will be very expensive. This may not be true. When a design alternative is considered at the very early stage of a project, or when a design is still on paper, it is always at minimal cost. What drives the cost up is the wait until the testing phase to find out problems and “improve” the quality. Hence, a cost benefits analysis should be incorporated into a Six Sigma program to measure the actual gains [36]. Researchers and practitioners are trying to integrate Six Sigma with other existing innovative management practices to make Six Sigma method even more attractive to different organizations under different conditions that might have not started or fully implemented the Six Sigma method [182]. Wherever the source of Six Sigma innovation may come from, Six Sigma continues to go from strength to strength [18].

Table 27 The Myths and Realities of Six Sigma

No	Myths	Myths Description	Myths Demystified
1	Six Sigma is the flavor of the month and as a management fad	Six Sigma was viewed as another repackaged quality trend that will come and go and is of no help to his company [75]. It is as an expensive distraction that requires paying a consultant to walk into an organization and teach a selected number of people "the newest best way" of problem solving. Six Sigma is as a fad with the same tools as employed in many other quality initiatives offered, e.g. TQM. News keeps cropping up about the efficacy of the Six Sigma business strategy from its critics, as a management fad – a fashion that sweeps the world with great excitement for a brief period of time, usually less than a year, and then disappears.	In reality, the concept of Six Sigma seems to have survived for nearly two decades despite the fact that many reports have classified it as a "management fad". Stories of success and dramatic improvement in business profitability of many organizations reflect the efficacy of this management strategy and can be considered as a classic example of "fit" rather than "fad". A fad is not simply good or bad. It is rather a matter of how it is put to use [75].
2	Six Sigma is all about statistics	Six Sigma was criticized for being heavily focus on training in various statistical tools and techniques and almost ignores the human factor (building of company culture by everybody's involvement and commitment for continuous improvement) [75]. One of the major hurdles service-oriented organizations must overcome is the notion that, because their company is human-driven, there are no defects to measure. This is wrong, say the experts. It is quite a common view among many people engaged in service organizations that Six Sigma requires complicated statistical tools and techniques [15].	Six Sigma is not just about statistics. Six Sigma drives for defect reduction, process improvement and customer satisfaction are based on the "statistical thinking" paradigm, a philosophy of action and learning based on process, variation and data. The truth is that Six Sigma is not about a collection of statistical tools and techniques but assisting the warrior team in project implementation. In reality, many service organizations simply do not need many of the tools and techniques of the Six Sigma toolbox [15].
3	Six Sigma is only for manufacturing companies	Six Sigma originated from Motorola in mid 1980's and was promoted by manufacturing giants like General Electric (GE) and Allied Signal, giving an impression that it can be deployed only in manufacturing companies [75]. Experts agree that the most common reason service-oriented organizations stay away from Six Sigma is that they see it as a manufacturing solution [15].	The relevance of Six Sigma has extended beyond manufacturing to services, government and public sector, healthcare and non-profit organizations [75]. In terms of expanding the horizons of Six Sigma, the two application areas that seem to be rising to the top of the heap are healthcare and financial services. The popularity of Six Sigma as a means of improving the quality of service and customer satisfaction is growing exponentially in the last couple of years in the European service industry. There are many reported and documented success stories of Six Sigma involvement in non-manufacturing industry.
4	Six Sigma works only in large organization	It is believed that Six Sigma application is restricted to large organizations only because of their endless resources and large teams [75]. Small companies might have a more difficult time to effectively implementing Six Sigma. It is still not sufficient documented evidence of its implementation in smaller organizations.	In reality, Six Sigma is about problem solving, and problems are everywhere. It does not matter what type or size of business this problem solving methodology is applied to. You might be a wholesaler, a retailer, a manufacturer, or a service organization. It does not matter whether it is a 300 employees company or a ten employees family business, Six Sigma will work as long as you follow the process effectively [75].
5	Six Sigma is the same as TQM	"Six Sigma is nothing new and it has been around for many years. It is just being called something else" [75]. It is true that Six Sigma employs some of the same tried-and-true tools and techniques of TQM. Many companies make the mistake of setting up Six Sigma as a quality initiative, putting it in the same category as TQM. Six Sigma has often been referred to as TQM on steroids [75].	"Six Sigma is not a program or an initiative" [75], there are aspects of Six Sigma strategy that are not emphasized in Total Quality Management (TQM). Firstly, Six Sigma is result-oriented and therefore it places a clear focus on bottom-line business impact in hard dollar savings. Six Sigma methodology DMAIC links the tools and techniques in a sequential manner. Furthermore, Six Sigma creates a powerful infrastructure for training of Champions, Master Black Belts, Black Belts, Green Belts and Yellow Belts. Therefore, Six Sigma should be viewed more as a holistic business strategy than as a quality program.
6	Six Sigma requires strong infrastructure and massive training	The process of deploying Six Sigma requires new skills, and this primarily means training the Black Belts and Green Belts who will guide and manage the improvement projects and programs. Employees or management team in the small businesses and public sectors have the misconception that Six Sigma demands massive training costs and additional effort [75]. It is true that Six Sigma requires some investment at the outset for training the most talented people in an organization and converting them into the so called "change agents" [15]. This high cost involvement in Six Sigma training creates a barrier for spending and prevents the implementation of improvement programs [49].	The deployment of Six Sigma knowledge should be done top down. The leaders of the company must first understand the basics of Six Sigma and develop a company-specific deployment strategy before building a Six Sigma infrastructure and beginning Black Belt and Green Belt training. It is advisable for SMEs to collaborate or develop some sort of consortium with local universities and get their best people trained up as Yellow Belts and White Belts to tackle their day-to-day problems. The training should focus on how to select the right projects and how to form the right teams so that the company's limited resources are effectively utilized.
7	Six Sigma is not cost effective	There are critics about Six Sigma heavy investments in business strategy which takes a long haul before reaping any tangible benefits. Six Sigma requires massive investments with merge profits or return on investment (ROI) [75].	Despite the massive investment, Six Sigma has generated substantial ROI in its implementation in the following examples. However, it is already a proven fact that the benefits obtained from Six Sigma implementation outweigh the investment costs [15] in Motorola (savings of $1 billion in 1998 and $16 billion in 2005), Dow Chemicals

No	Myths	Myths Description	Myths Demystified
			(achieved its target of $1.5 billion in cumulative EBIT (earnings before interest and taxes) gains by the end of 2002) and Volvo Cars (generated over 55 million euro in Sweden).
8	Six Sigma only provides initial or kick-start benefits to organization	Six Sigma project selections for investment should be aligned with the customers' needs and should have the potential to significantly improve the bottom-line [75]. Organizations embracing Six Sigma can achieve better quality and efficiency in the flow of information and interaction between people, especially interaction with customers. The process of Six Sigma identifies the voices of customers and maps it in the form of matrix (cause and effect matrix) or house of quality (quality function deployment).	At the same time, it engages employees and customers in greater dialogue in a way that both energizes and unites the company. Problems are analyzed, and solutions are implemented not only between the business and its employees but also between the business and its customers. From the bottom-line, the cultural change in a Six Sigma organization is facilitated by key players known as Champions and Black Belts, who act as agents to facilitate the change [75]. Six Sigma provides bottom-line benefits and customer-oriented management
9	Six Sigma required additional knowledge for implementation	In the knowledge management, the CSUE cycle [103] is recommended just like the DMAIC cycle in Six Sigma. The CSUE cycle is creating and capturing, storing and sharing, utilization, and evaluation. It means that knowledge should be created or captured at the beginning, and then it should be stored and shared. Next, it should be utilized for process improvement, and then it should be evaluated for further use later [75].	The DMAIC cycle can be practically useful for knowledge management, and it can be linked well with the CSUE cycle are: (1) Define – fact finding ; (2) Measure – data gathering ; (3) Analyze – information creation and capturing ; (4) Improve – knowledge sharing and utilization and (5) Control – knowledge maintaining and evaluation. Definitely Six Sigma and knowledge management can be combined, and so-called knowledge-based Six Sigma. Six Sigma and matches well to knowledge-based information society

Source: Research analysis compilation

Chapter-4 Research Methodology and Research Design

4.1 Introduction

Research is the systematic investigation into existing or new knowledge. It is used to establish or confirm facts, reaffirm the results of previous work, solve new or existing problems, support theorems, or develop new theories. A research project may also be an expansion on past work in the field. **Research methods** describe the philosophical basis of a research approach. At this stage, no concern is given to the specific activities involved or the precise order in which they are conducted [183]. In order to address this need, it is necessary to adopt an approach to research that responds to industry problems and facilitates the orderly evaluation, adoption and continuous improvement of research outputs. Flint had presented four research methods tabulated in Table 28 as part of a conceptual model of software engineering research:

Table 28 Types of Research Methods [183]

No	Type of Research Methods	Description
1	**Scientific Method**	Observing the world, propose a model or theory of behavior, measure and analyze, validate hypothesis of the model or theory, and, if possible, repeat.'
2	**Engineering Method**	Observing existing solutions, propose better solutions, build or develop, measure and analyze, and repeat until no further improvements are possible.'
3	**Empirical Method**	Proposing a model, develop statistical or other methods, apply to case studies, measure and analyze, validate the model, and repeat.'
4	**Analytical Method**	Proposing a formal theory or set of axioms, develop a theory, derive results, and, if possible, compare with empirical observations.'

4.2 Types of Research Approach

This chapter outlines different research approaches in the social and behavioral sciences. There exists three categories of research approaches of **Quantitative Approach**, **Qualitative Approach** and **Mixed Method Approach**. These three methodological movements share similar background, methodological, orientations, research ideas and practices [184]. However, there appear to be basic "cultural" differences between these researchers in terms of the manner in which they are trained, the types of research programs they pursue, and the types of professional organizations and special interest groups to which they belong. These cultural differences contributed to a distinct sense of community for each group.

There is no one ideal structure for research approach, a reasonable approach to a problem in social science proposed by Hunt & Colander [185] is in the following sequence: (1) Observe ; (2) Define the problem ; (3) Review the literature ; (4) Observe some more ; (5) The generation of models, theories and hypotheses ; (7) The development of instruments and methods for measurement ; (8) Experimental control and manipulation of variables ; (9) Choose the research design ; (10) Collection of empirical data ; (11) Modeling and analysis of data ; (12) Draw conclusions.

The best way to know about the real world is to observe it. Defining the problem is probably the most important steps in the process of research; you can save an enormous amount of energy of you have your problem carefully defined. Knowledge of the relevant literature is essential because it provides background, suggests approaches, indicates what has already been covered and what hasn't, and saves you from redoing what has already been done. Next, make a statement predicting one result and then clarify what each of the term in the statement means within the framework of your research. Pick a means of gathering data and weigh the choice carefully.

Once data are collected, analyzed the data and classify data in facts, trends, recognize relationships; and tabulate the information so that it can be accurately analyzed and interpreted. Lastly, draw conclusion on the hypothesis; whether to confirm, reject or modify the hypothesis. The above steps differ slightly from the natural science approach and the primary difference comes in how a hypothesis is tested.

4.3 Type of Research

4.3.1 Quantitative Research

Quantitative research refers to the systematic empirical investigation of social phenomena via statistical, mathematical or computational techniques [186]. It is numerically oriented, requires significant attention to the measurement of market phenomena and often involves statistical analysis [187]. Its' purpose is to make cause and effect statements where experiment is needed to manipulate (or treatment) variables. The strategies of inquiry associated with quantitative research were those that invoked the post-positivist worldview [188].

It is a means of testing objective theories by examining the relationship among variables. The final written report has a set structure consisting of introduction, literature and theory, methods, results and discussions. The strategies of quantitative research inquiry include true experiments, survey; the less rigorous experiments called quasi-experiments and correlational studies and specific single-subject experiments [184, 187, 188]. The types of quantitative research are survey research, experiment research, quasi-experiment design, correlation design and quantitative data collection as describe in Table 29.

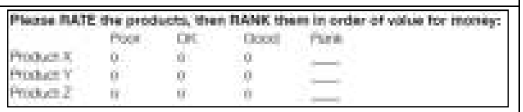
Table 29 Different Types of Quantitative Research

Quantitative Research	Description
Survey Research	Survey research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population [188]. It includes **cross-sectional** and **longitudinal studies** using questionnaires or structured interviews for data collection, with the intent of generalizing from a sample to a population [188]. Surveys come in a wide range of forms and can be distributed using a variety of media and medium. According to a survey guideline website [189], there are three types of surveys: **Written Surveys (**Mail Surveys, Group Administered Questionnaires and Drop-off Surveys), **Oral Surveys (**Interview (Individual and Group) and Phone Survey) and **Electronic Surveys.** Table 31 summarizes the advantages and disadvantages for each survey methods and Table 30 summarizes different question types for basic questionnaire design. It is important to spend some time knowing each survey method and its outcome to optimize research efficiency and effectiveness. **Cross-sectional design** often uses survey methods, and surveys are often equated with cross-sectional studies [190]. Other methods of data collection are observation, content analysis and official records. **Longitudinal design** consists of repeated cross-sectional surveys to ascertain how time influences the results. The repeated nature of the research design is the reason for it being expensive and time consuming, unless it relies on information that has already been collected as a matter of course within an organization [190]. Surveys are the best way to collect a large amount of data from a large number of people in a short amount of time. Surveys are very robust and can be used in many life domains [191]. The examples of survey are telephone surveys, mail surveys, web/email surveys, face-to-face interviews and observations.
Experiment Research	It is characterized by randomization of subject, introduction of a treatment and control over variables [187]. Experiment research seeks to determine if a specific treatment influences an outcome. This impact is assessed by providing a specific treatment to one group and withholding it from another and then determining how both groups scored on an outcome

Quantitative Research	Description
	[188]. When the researchers has the study established and is amenable to experimental methods, a prediction (technically called a hypothesis) of the likely cause-and-effect patterns of the phenomenon has to be made. The researcher strives to isolate and control every relevant condition which determines the events investigated, so as to observe the effects when the conditions are manipulated [185, 190]. This allows decisions to be made as to what variables are to be tested and how they are to be controlled and measured.
Quasi-Experiment Design	A quasi-experiment is a study that takes place in real-life settings as opposed to a laboratory [191]. In this approach, not all the conditions of true experimental design can be fulfilled. However, the nature of the shortcomings is recognized, and steps are taken to minimize them to predict a level of reliability of the results [190]. The subjects of Quasi-experimental are not randomized where researchers employing a quasi-experimental method will use intact groups of subjects. Since it is not randomized, researcher needs to do something to establish the comparability of the groups in order to draw on the power of the experimental method. The authors Vanderstoep & Johnston [191] shared an example of quasi-experimental design where the effects of a student diversity program at an university in the western United States was examined: "in this quasi-experiment, the researcher compared students who participated in the diversity program to students who did not participate. Their dependent variables were, among other things, GPA and graduation rate. They found no significant difference between the two groups on GPA, but found that those who took the diversity program had higher graduation rates than those who did not participate in the program. The conclusion from the data seems straightforward: providing students with diversity training increases graduation rates."
Correlation Design	According to Walliman [190] "Correlation design looks for cause-and-effect relationships between two sets of data, which ex post facto design turn experimentation into reverse, and attempt to interpret the nature of the cause of a phenomenon by the observed effects. Both of these forms of research result in conclusions which are difficult to prove and they rely heavily on logic and inference." It involves identifying relationship between two variables and a correlation has a direction and a magnitude. A positive correlation exists when, as one variable increases (or decreases), the other variable also increases (or decreases) [191]
Quantitative Data Collection	Most of the quantitative researches are done face-to-face. One of the best-known techniques is research group discussions (or **focus groups**). These are usually made up of 6 to 8 targeted respondents, a research moderator whose role is to ask the required questions, draw out answers, and encourage discussion, and an observation area usually behind one way mirrors, and video and audio taping facilities [192]. The most common quantitative technique is the 'survey'. Quantitative **surveys** can be conducted by using post (self-completion), face-to-face (in-street or in-home), telephone, email or web techniques. The **questionnaire** is one of the more common tools for collecting data from a survey, but it is only one of a wide ranging set of data collection aids. The main rule with quantitative research is that every respondent is asked the same series of questions. The approach is very structured and normally involves large numbers of interviews and questionnaires.

Source: Research analysis compilation

Table 30 Different Types of Questions

No	Question Type	Descriptions, Advantages and Disadvantages	Example
1	**Contingency questions** [193]	• A question that is **answered** only if the respondent **gives** a particular response to a previous question. • This avoids asking questions of people that do not apply to them	Asking a man if he has ever been pregnant before.
2	**Matrix questions** [193, 194]	• Identical response categories are assigned to multiple questions. • The questions are placed one under the other, forming a matrix with response categories along the top and a list of questions down the side. • This is an efficient use of page space and respondents' time	
3	**Closed ended questions** [193-196]	• Respondents' answers are limited to a fixed set of responses. • Most scales are close-ended **Advantages** • More easily analyzed and higher response rate • Better suited for computer analysis • No coding system required and preserve its initial meaning • Responses and questions can be more specific and is likely to communicate similar meanings • Interviewer required less time to complete the survey • Less costly as compare to open-ended questions **Disadvantages** • Not allowing respondents to reflect true feelings	• **Dichotomous Question** o **Yes/No** questions o **True/False** question o **Agree/Disagree** question o **Male/Female** question • **Multiple choice** - The respondent has several option from which to choose. • **Scaled questions** – e.g. the Likert scale, semantic differential scale, and rank-order scale. Responses are graded on a continuum (example : rate the appearance of the product on a scale from 1 to 10, with 10 being the most preferred appearance). Examples of types of scales include (See scale for a complete list of scaling techniques.).
4	**Open ended questions** [193, 196]	• No options or predefined categories are suggested. • The respondent supplies their own answer without being constrained by a fixed set of possible responses **Advantages** • Include more information such as feeling, attitudes and subject matter • Allow secondary analysis especially on demographic information	• **Completely unstructured** – E.g. "What is your opinion of questionnaires?" • **Word association** - Words are presented and the respondent mentions the first word that comes to mind. • **Sentence completion** – E.g. "The most important consideration in my decision to buy a new house is . . ." • **Story completion** - Respondents complete an

No	Question Type	Descriptions, Advantages and Disadvantages	Example
		Disadvantages • Required coding system and are tend to lose some of the initial meaning	incomplete story. • **Picture completion** - Respondents fill in an empty conversation balloon. • **Thematic apperception test** - Respondents explain a picture or make up a story about what they think is happening in the picture

Source: Research analysis compilation

Table 31 Advantages and Disadvantages of Survey Methods

No	Types	Method	Advantages	Disadvantages
1	Written Survey	Postal / Mail Survey [189, 193]	• Low cost-per-response. • Convenient to work on survey at leisure • Little chance on personal bias • Greater sampling-internal link	• Subject to postal delays (especially substantial when posting to remote areas) or unpredictable events such as natural disasters. • Survey participants can choose to remain anonymous. • It is not labour intensive. • Low response rate as compare to face-to-face and telephone survey • Ability of respondent to answer survey
		Group Administered Questionnaire [189]	• Higher response rate as compare to postal survey • Allows specificity of various questions	• Small sampling • Scheduling is a nightmare
		Drop-off Surveys [189]	• Convenient to work on survey at leisure • Better response rate as compare to mail survey	• Takes up more time as compared to mail survey • Smaller pool of sample as compared to mail survey • Response rate is moderate only as compared to oral survey, but better than the mail survey
2	Oral Surveys	Telephone [189, 193]	• Questionnaires can be conducted swiftly. • Rapport with respondents, allows personal contact • High response rate • Offers flexibilities reacting to respondents answer • Ability to control the response rate	• Be careful of sampling so that it doesn't skew the sample • Are more prone to social desirability biases than other modes, so telephone interviews are generally not suitable for sensitive topics • Costly and bias • Limit in type of questions possible. Special care is needed while constructing questions for phone survey • Affecting respondent attitude towards the survey after interruption
		Interview / Personally Administered [189, 193]	• Allows personal contact and allow rapport with respondents is generally higher than other modes • Offers flexibilities reacting to respondents answer • Ability to control the response rate and typically higher response rate than other modes. • A convenience (vs. a statistical or representative) sample to generalize results. However, use of rigorous selection methods (e.g. those used by national statistical organizations) can result in a much more representative sample	• Costly and bias • Affecting respondent attitude towards the survey after interruption • Limit in type of questions possible • Respondents are often limited to their working memory: specially designed visual cues (such as prompt cards) may help in some cases. • Can be extremely expensive and time consuming to train and maintain an interviewer panel.
3	Electronic Survey	Online / Electronic Surveys [189, 193, 197, 198]	• Ability to access unique population • Save time where researcher could reach thousands of people with common characteristics in a short amount of time • Questionnaires can be conducted swiftly, without postal delays. • Survey participants can choose to remain anonymous, though risk being tracked through cookies, unique links and other technology. • Work well if survey contains several branching questions. • Cost-savings, faster transmission time, ease of editing, analysis and easy use of	• Sampling issue where there is no guarantee that participants from previous surveys provide accurate demographic or characteristics information • Access issue. Members of online communities often find this behavior rude or offensive, or consider this type of posting to be "spam” • Initial set-up costs can be high for a customized design and it is not labour intensive. • Questions can be more detailed, as opposed to the limits of paper or telephones. • Not all of the sample may be able to access the electronic form, and therefore results may not be representative of the target population.

No	Types	Method	Advantages	Disadvantages
			Pre-letters • Higher Response Rate as compare to paper survey or interviews • More Candid Responses with more honest respondents • Potentially Quicker Response Time with Wider Magnitude of Coverage • Presentational and multimedia benefits	• Sample Demographic Limitations, Lower Levels of Confidentiality, Layout and Presentation issues and Additional Orientation/Instructions • Potential Technical Problems with Hardware and Software • Lack of trust in technologies concern of anonymity, confidentiality, data security and delivery • Required longer download time with larger files for visual and multimedia presentation

Source: Research analysis compilation

4.3.2 Qualitative Research

Qualitative Research aims in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences. In short, **Qualitative research** provides an understanding of how or why things are. It is a descriptive research where the researcher makes observations of a specific situation. It's aims are to identify key variables in the particular situation that may prove useful in framing questions to be explored further by qualitative research or by other modes of inquiry [187].

Qualitative Research encompasses a number of philosophical orientations and approaches [199]. Qualitative Research helps us to understand apparently illogical behaviors; allowing us to access the "embedded" processes by focusing on the context of people's everyday lives, where such decisions are made and enacted [200]. Qualitative Research is particularly well suited to studying context. It also excels at illuminating process, whether it is organizational change or individual decision-making, since it allows us to examine how changes affect daily procedures and interactions. This may lead the researcher uncovering unintended as well as intended consequences of new arrangements [200].

There are a variety of qualitative strategies and the most commonly used approaches reviewed by Merriam [199] which falls under the umbrella concept of "qualitative" are basic qualitative research, phenomenology, grounded theory, ethnography, narrative analysis and critical qualitative research. Last but not least, case study approach is a very common design in qualitative research. The types of qualitative research are summarized in Table 32.

Table 32 Different Types of Qualitative Research

Qualitative Research	Description
Basic Qualitative Research	Basic qualitative research is interested in how meaning is constructed, how people make sense of their lives and their worlds. The primary goal of a basic qualitative study is to uncover and interpret these meanings. It can be found throughout the disciplines and in applied fields of practice. This is the most common form of qualitative research found in education [199]. Data are collected through interviews, observations, or document analysis [199, 200]. The analysis of data involves identifying recurring patterns or themes supported by the data from which they derived.
Phenomenology	Phenomenology is a study of people's conscious experience of their life-world or their "everyday life and social action" [199, 201]. It is all about focusing how experiencing something is transformed into consciousness [191]. The primary method of data collection is phenomenology interview where researcher usually explores his/her own experiences, in part to examine dimensions of the experience and in part to become aware of personal prejudices, viewpoints and assumptions. It is a strategy of inquiry in which the researcher identifies the essence of human experiences about a phenomenon as described by participants. Understanding the lived experiences marks phenomenology as a philosophy as well as a method, and the procedure involves studying a small number of subjects through extensive and prolonged engagement to develop patterns and relationships of meaning [188]. Therefore, phenomenology approach is well suited to studying effective, emotional and often intense human experiences. Hence,

Qualitative Research	Description
	it is important to understand phenomenology as a philosophy which has had an impact on all of qualitative research [199].
Grounded Theory	Grounded Theory is a specific research approach where the investigator as the primary instrument of data collection and analysis assumes an inductive stance and strives to derive meaning from the data [199]. The end result is a theory that emerges from its "grounded" data which later become the grounded theory. Data in grounded theory studies come from interviews, observations and a wide variety of documentary materials. Data collection is guided by theoretical sampling in which "the analyst jointly collects, codes and analyses data and decides what data to collect next and where to find them, in order to develop the grounded theory" [3]. This process involves using multiple stages of data collection and refinement and interrelationship of categories of information [188].
Ethnography	Ethnography is likely to be the most familiar to researchers [199]. It is both a process and a product and there are many forms of ethnography such as life history, critical ethnography, auto-ethnography and feminist ethnography. Ethnography focuses on human society and culture which refers to the beliefs, values and attitudes that structure the behavior patterns of a specific group of people [187, 188, 191]. Therefore, in order to understand the culture of a group, one must spend time with the group being studied [191, 199]. One of the primary methods of data collection is the immersion in the site as a participant observer. The ethnographer sees the practices of a culture as reflections of the cultural past, performances of the cultural present, and directions for cultural change and growth [191]. Interviews, formal and informal and the analysis of documents, records and artifacts also constitute the data set along with a fieldwork's diary of each day's happenings, personal feelings, ideas, impressions or insights with regard to events [199]. In summary, to be an ethnography study, understanding the culture of phenomenon is necessary.
Narrative Analysis	"The oldest and most natural form of sense making" are stories or narratives [199, 202]. The researcher studies the lives of individual and asks one or more individuals to provide stories about their lives. The information is the often retold or re-storied by the researcher into a narrative chronology. In the end, the narrative combines views from the participant's life with those of the researcher's life in a collaborative narrative [188]. Stories are how we make sense of our experiences, how we communicate with others, and through which we understand the world around us [199]. Stories are also called "narratives" have become a popular source of data in qualitative research. Other terms of stories of experience are biography, life history, oral history, auto-ethnography and auto-biography. Narrative research makes use of various methodological approaches to analyzing stories; each approach examines how the story is constructed, what linguistic tools are used, and the cultural context of the story. Hence, when the substance of the narrative identifies the events and their sequence of occurrence, the meaning of the actions and the resolution will finally happen.
Critical Qualitative Research	In critical inquiry, the goal is to critique and challenge, to transform and empower [199]. Power dynamics are at the heart if critical research. Questions are asked about who has power, how it is negotiated, what structures in society reinforce the current distribution of power. The "critical incident technique" embodies an idea very similar to that informing the notion of "analytic induction", which refers to the important role played by exceptions in the process of analysis and refining for explanatory framework [200]. It raises question about how power relations advance the interests of one group while oppressing those of other groups, and the nature of truth and the construction of knowledge. Critical research can be combined with other qualitative methodologies. Critical research often covers the lenses of critical race theory, critical gender studies and critical management studies etc. Collective action and theories as a result of the investigation is a crucial component of critical research.

Source: Research analysis compilation

4.3.3 Mixed Method Research

Mixed Methods research was defined as "research in which the investigator collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches and methods in a single study or program of inquiry" [184]. The objective is to employ multi-method matrix to examine multiple approaches to data collection [188]. As a result, the approaches associated with field methods such as observation and interviews (qualitative data), were combined with traditional survey (quantitative data).

The mixed methodologists works primarily within the pragmatist paradigm and interested in both narrative and numeric data and their analysis and similarly it can simultaneously address a range of both confirmatory and exploratory questions [184]. Mixed Methods research uses both deductive and inductive logic in a distinctive sequence as in the **inductive-deductive research cycle** [184]; moving from grounded results (observations, facts) through inductive reference to general inferences, then from those general inferences (or theory, conceptual framework, model) through deductive inference to predictions to the particular hypotheses [184]. In the inductive-deductive research cycle, either the induction or deduction could come first depending on the term of study the phenomenon of interest.

By recognizing that all methods have limitations, researchers felt that biases inherent any single method could neutralize or cancel the biases of other method [188]. Therefore, by early 1990s, the idea of mixing moved from seeking convergence to actually integrating or connecting the quantitative and qualitative data. According to Creswell [188], result from one method can help identify participants to study or questions to ask for the other method. Alternatively, the collection of qualitative and quantitative data can merged into one large single repository or the results can be used side by side to reinforce each other [188]. In general, there are three strategies of mixed methods research discussed by Creswell [184]: (1) Sequential Mixed Methods; (2) Concurrent Mixed Methods; (3) Transformative Mixed Methods. The types of mixed method research are summarized in Table 33:

Table 33 Type of Mixed Method Research [184]

Type of Mixed Method	Description
Sequential Mixed Methods	Researchers seek to elaborate on or expand on the findings of one method with another method. This may involve with a qualitative interview for exploratory purpose and following up with a quantitative, survey method with a large sample so that the researcher can generalize results to a population. Alternatively, a study may begin with a quantitative method in which a theory or concept is tested, followed by a qualitative method involving detailed exploratory with a few cases or individual.
Concurrent Mixed Methods	Researchers converge or merge quantitative and qualitative data in order to provide a comprehensive analysis of the research problem. The investigator collects both forms of data at the same time and then integrates the information in the interpretation of the overall results. Researchers also allow to embedded one smaller form of data within another larger data collection in order to analyze different types of questions; i.e. qualitative addresses the process while the quantitative addresses the outcomes.
Transformative Mixed Methods	Researchers use a theoretical lens as an overarching perspective within a design that contains both quantitative and qualitative data. This lens provides a framework for topics of interest, methods for collecting data, and outcomes or changes anticipated by the study. Within the lens itself, data collection methods involved a sequential or a concurrent approach

4.3.4 Case Study Approach

4.3.4.1 Introduction

A case study is an in-depth description and analysis of a bounded system [199]. The case study is one of several ways of doing social science research, other ways include experiments, surveys, histories and the analysis of archival information [191, 203]. The case study is not in itself a research method, rather it is an approach to social research with various methods [187, 204]. Case Study approach usually concentrates on a single case – an individual, an event, or an organization [190, 191] and is bounded by time and activity [188]. This approach is intensive, with the aim to discover something about the unique nature of the case using diaries, observations, interviews, questionnaires, in fact anything that might offer an insight into a case [204]. Both quantitative and qualitative methods are appropriate for case study design, and multiple methods of data collection are often applied [190].

In general, case studies are the preferred strategy when "how" or "why" question are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context [199, 203]. The case study research has been adopted in many areas such as psychology, sociology, political science, social work as well as business

[205] where this strategy allows investigators to retain the holistic and meaningful characteristics of real-life events – such as individual life cycle, organizational and managerial processes, neighborhood change, international relations, and the maturation of industries [203]. Case studies design is appropriate for both quantitative and qualitative methods [190].

4.3.4.2 When to Use Case Study Strategy

There are times when one uses Case Study approach to study a social group, community, system, organization, institution, event, or even a person or type of personality. A small number of examples or one example are pick up to perform detail analysis within its' own context and make assessments and comparisons [190]. This approach is based on the view that the more people for whom a prediction holds true, or across whom observations are consistent, then the more likely the study to accept a hypothesis and provide evidence for a theory. However, there are certain situations in which it might not be possible to conduct research in the conventional way [204]. In order to decide when to use case study strategy, the author looks into the following three condition as specified by Yin [203] in Table 34:

(a) The type of research question posed
(b) The extent of control an investigator has over actual behavioral events
(c) The degree of focus on contemporary as opposed to historical events

Table 34 Relevant Situation for Different Research Strategies

Strategy	Form of Research Question	Requires Control of Behavioral Events?	Focus on Contemporary Events?
Experiment	How, Why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival analysis	Who, what, where, how many, how much?	No	Yes/No
History	How, Why?	No	No
Case Study	How, Why?	No	Yes

Source: COSMOS Corporation, Yin [203]

4.3.4.3 Type of Case Study Research Questions

A series of basic categorization scheme for the types of questions by Yin [203] are "who", "what", "where", "how" and "why". If the research question mainly focuses on "what" exploratory questions, conducting an exploratory study (i.e. exploratory experiment, exploratory survey, or exploratory case study) can lead to develop pertinent hypotheses and propositions for further inquiry. If the "what question is actually the form of a "how many" or "how much" line of inquiry, a survey or archival strategies would be in favour. Similarly, when the "how" and "why" questions are more explanatory which deal with operational links needing to be traced and tracked over time, this will lead to case study strategy [203]. It is less likely for the author to reply on a survey or an examination of archival records where history or a case study would be a better alternative.

In short, "what" questions that falls into exploratory can use any of the strategies; the "what" prevalence question can be in favor of surveys or analysis of archival records. "How" and "why" question are likely to favor the use of case studies, experiments, or histories.

4.3.4.4 Case Study Research Control Variables

In this section, the study is focusing on the extent of control an investigator has over actual behavioral events and degree of focus on contemporary as opposed to historical events. The next level determining the use of each strategy distinction among history, case study and experiment is the extent of the investigator's control over and access to actual behavioral events. **Histories** are the preferred strategy when there is virtually no access or control. In some cases, histories can be done for contemporary events but may overlap with case study. **Case study** is preferred in examining contemporary events, but when the relevant behaviors cannot be manipulated. Case study has added two sources of "direct observation" of the events being studied and interviews of the persons involved in the events. **Experiments** are done when an investigator can manipulate behavior directly, precisely and systematically. There would be cases where the identified situations in which all research strategies might be relevant and other situation in which two strategies might be considered equally attractive. For the case study approach, a "how" or "why" question is being asked about a contemporary set of events, over which the investigator has little or no control.

4.3.4.5 Advantages and Disadvantages of Case Study Approach

The case study has the ability to deal with a full variety of evidence ranging from documents, arti-facts, interviews and observation which beyond what might be available in a conventional historical study. As with all previous methods of research, the case study is not without its own problems. It was a challenge of selection sample(s) for case study investigation as the sampling choice need to be reassured the cases are representative [190, 191]; this is to ensure an "average" or representative cases has been achieved [190]. This "generalization" problem may sometimes be difficult to expand findings from a study involving a sample to the population as a whole [204]. Observer biases; an observer may well attend selectively to the presented information may overvalue some events at the expenses of others and may even be guilty of a form of motivated perception, if the aim of a study is to promote a favored belief or theory [204]. Besides, the subject itself, is relying on memory or introspection to provide descriptions of experiences and emotions, may fall victim to the many factors that influence our recall for past events [204].

One solution is to take a comparative approach by selecting several very different samples showing extreme characteristics and perhaps one sample that is somewhere in the middle and compare their characteristics. Alternatively, choose an "exemplifying" or "critical" case, one that will provide a good setting for answering the research question [190]. However, when a broader perspective is the aim, a case study could be used to provide a first, tentative hypothesis about human behavior, which would be the starting point of a larger piece of research.

4.4 Comparisons Between Qualitative and Quantitative Research

Table 35 outlines a comparison of characteristics of qualitative research with quantitative approach by Merriam [199] somewhat artificial dichotomy between the two types; which should be viewed as an aid to understand differences, not as a set of hard-and-fast rules governing each type of research. Quantitative research tends to measure, qualitative research tends to describe [190].

The distinctions are useful in describing and understanding social research and management research and do not suggest that one approach is better than the other. Walliman [190] identified the distinction between qualitative and qualitative techniques as following: “Quantitative techniques rely on collecting data that is numerically based and amenable to such analytical methods as statistical correlations, often in relation to hypothesis testing. Qualitative techniques rely more on language and the interpretation of its meaning, so data collection methods tend to involve close human involvement and a creative process of theory development rather than testing. Furthermore, quantitative research can be carried out from an interpretivist perspective, as can qualitative research from one of natural science”

Table 35 Characteristics of Qualitative and Quantitative Research

Point of Comparison	Qualitative Research	Quantitative Research
Focus of research [191, 199]	Quality (nature, essence)	Quantity (how much, how many)
Purpose and Design characteristics [191, 199]	Description, Flexible, evolving, emergent	Prediction (Predetermined), structured
Philosophical roots [199]	Phenomenology, symbolic interactionism, constructivism	Positivism, logical empiricism, realism
Orientation [190, 191]	Inductive approach to test theories	Deductive approach to test theories
Associated phases [199]	Fieldwork, ethnographic, naturalistic, grounded, constructivist	Experimental, empirical, statistics
Epistemology [190]	Rejects positivism approach	Based on positivism approach
Goals of investigation [199]	Understanding, description, discovery, meaning, hypothesis generating	Prediction, control, description, confirmation, hypothesis testing
Ontology [190]	Constructionist (constant shifting product of perception)	Objectivist (social reality as objective fact)
Sample [199]	Small, non-random, purposeful, theoretical	Large, random, representative
Data Collection [199]	Researcher as primary instrument, interviews, observations, documents	Inanimate instruments (scales, tests, survey, questionnaires, computers)
Primary mode of analysis [199]	Inductive, constant comparative method	Deductive, statistical
Findings [191, 199]	Comprehensive, holistic, expansive, richly descriptive, adequate and realistic	Precise, numerical, statistics, replication, cumulative
Example [199]	Finding out how people adjust to retirement, how they think about this phase of their lives, the process they engaged in when moving from full-time work to retirement	Finding out how many retired folks take on part-time jobs after retirement (using survey)

Source: Research analysis compilation

4.5 Comparisons Between Qualitative, Quantitative and Mixed Methods Research

It is important in a research framework to decide on a research method for data collection, analysis and interpretation. Researchers collect data on an instrument or test (e.g. a set of questions) or gather information on ha behavioral checklist (e.g. observation); collecting data involve visiting a research site and observing the behavior of individual without predetermined questions or conducting an interview in which the individual is allowed to talk openly about a topic [184]. In some cases, the research required making interpretations of statistical results, or they interpret the themes or patterns that emerge from the data. In some forms of research, both quantitative and qualitative data are collected, analyzed and interpreted [184]. Instrument data may be augmented with open-ended observation, or census data may be followed by in-depth exploratory interview. In this case of mixing methods, the researcher makes inferences across both the quantitative and qualitative databases. Table 36 summarizes the dimensions of contrast among the three methodological communities and their separate points of views and may be useful in choosing an approach.

Table 36 Dimension of contrast among Quantitative, Qualitative and Mixed Methods Approach

Dimension of Contrast	Quantitative	Qualitative	Mixed Methods
Strategy of Inquiry [184, 188]	• Experiment designs • Non experimental designs (e.g. survey)	• Narrative research • Phenomenology • Ethnography • Grounded theory studies • Case Study	• Sequential • Concurrent • Transformative
Data collection methods [188]	• Pre-determined • Instrument base questions • Performance data, attitude data, observational data and census data • Statistical analysis • Statistical interpretation	• Emerging methods • Open-ended questions • Interview data, observation data, document data, and audio-visual data • Text and image analysis • Themes, patterns interpretation	• Both pre-determined and emerging methods • Both open-ended and closed-ended questions • Multiple forms of data drawing on all possibilities • Statistical and text analysis • Across databases interpretation
Paradigms [184, 188]	• Post-positivism • Positivism	Constructivism (and variants)	Pragmatism; transformative perspective
Form of Data [184]	Typical numeric	Typical narrative	Narrative plus numeric
Purpose of research [184]	(Often) confirmatory plus exploratory	(Often) exploratory plus confirmatory	Confirmatory plus exploratory
Role of theory [184]	Rooted in conceptual framework or theory; hypothetic-deductive model	• Grounded theory • Inductive logic	• Both inductive and deductive logic • Inductive-deductive research cycle
Sampling [184]	Mostly probability	Most purposive	Probability, purposive and mixed

Source: Research analysis compilation

4.6 Thesis Research Strategy

4.6.1 Research Strategy – Case Study Approach

The conceptualization and development process of a framework of implementing Six Sigma into Malaysia's SMEs IT industry requires an understanding of the research background, research environment and research requirements. Typically, the concept and knowledge of research methods is important so as the "best practices" can be applied to specific case or scenario to attain research objectives.

In search for knowledge, facts and truth about this study; different types of research approaches and comparison among them were discussed in Section 4.2, 4.3, 4.4 and 4.5. The research strategy adopted for this study is an exploratory case study method. The focus of attention for this study is to explore the feasibility analysis of Six Sigma implementation in Malaysian IT industry in the business area of IT Service, IT Products and IT Process.

Case study is an empirical approach that allows in-depth study of any IT community amongst Malaysian SMEs by investigate a phenomenon of Six Sigma implementation within the context of IT project management. This research topic aims to explore the opportunity of Six Sigma innovation beyond manufacturing into the IT industry, hence a case study approach is the best method to challenge theoretical assumptions and facilitate discovery of hidden truths by providing more realistic responses than a purely statistical survey. Therefore, the case study approach obtains a complete picture by employing a mixed method of qualitative and quantitative approaches.

During the initial stage, the case study research undertaken involved a quantitative data analysis and statistically discovered the trend and pattern of QIM adoption among the Malaysian IT companies, a lacking of success stories of Six Sigma implementation among the Malaysian IT industry, a common set of tools and techniques applied among the IT companies and a new understanding of interrelationship between different IT business areas. These proven knowledge-based outcomes from the quantitative findings are later used as fundamental guidance to extend the research study into Six Sigma implementation to three Malaysian IT case companies.

The design of a case study is always a challenge to researchers as it is hard to generalize a single case approach across most scenarios. A good case study requires proper planning and designing to keep the study focused, concise and ensure the data collected is relevant and of greater depth than other experimental designs [184]. In this study, the approach of "The Six Sigma Way" of five-phases improvement cycle case study approach is adopted especially in this case of rare phenomena to explore the feasibility of Six Sigma as a QIM into SMEs in the Malaysian IT companies.

During the implementation of the Six Sigma case study approach, combinations of quantitative and qualitative approaches are achieved. This exploratory case study employs artifacts gathered from literature reviews, examination of documents, archival records, semi-structured interviews, direct and indirect on-the-job training and observation into the case companies. Typically, the qualitative methods of grounded theory, phenomenology, ethnography and narrative analysis with the aid of Six Sigma tools and techniques such as FMEA, Cause-and-Effect diagram, High-level process mapping and Input-Process-Variables are used to interpret and understand the patterns and relationships of findings derived from quantitative methods in this study [11, 107, 115, 180]. The data collection and analysis methods used in this study is a result of collective literature reviews from Section 3.5.2.

One of the main criticisms of case study is that the data collected cannot be generalized to the wider population and hence the collected data are not always being relevant or particularly useful.

This is not true as the directive of this study drives towards the need of each case company to be carried out uniquely into three business areas to allow the investigation process addresses a broader range of behavioral and attitudinal issues relative to the case companies as each case company has a different business nature and has unique commercial objectives [184]. The case study approach has allows the conceptualization and formation of Six Sigma implementation and integration framework in the Malaysia IT industry. The framework outlines seven criteria of assessment to discover its co-relation and interdependency contributing to the decision-criteria for Six Sigma implementation as well as integration of existing QIM with Six Sigma for quality improvement methodology.

Despite of the common drawbacks about the case study approach, the data collected from quantitative and qualitative approach is a lot richer and of greater depth compared to other experimental designs; and this has helped to produce new ideas and new findings in this study which later was interpreted and understood with the help of tools and techniques applied from the Six Sigma way. The adopted research strategy of case study approach within the improvement cycle of DMAIC and DFSS phases have addressed the research questions and research hypotheses of this thesis.

4.6.2 Research Workflow

Figure 8 describes the high-level research workflow adopted in this study and the time frames of the exploratory case studies undergone Six Sigma implementation or integration with existing QIM is running in parallel as follows:

- Company–A, IS Support (IT Service & IT Process) : August 2012 to September 2013
- Company–B, SYNDES (IT Product & IT Process) : August 2012 to September 2013
- Company–C (IT Service & IT Process) : November 2012 to March 2014

Source: Research analysis compilation

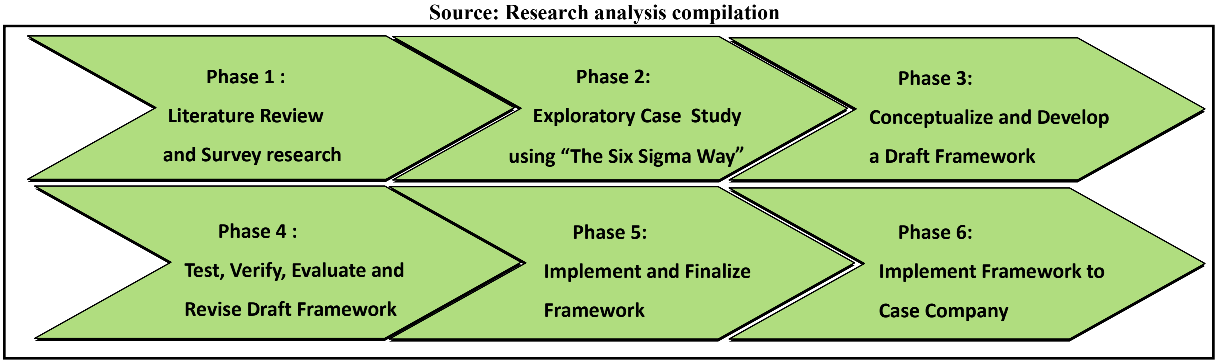


Figure 8 The Research Workflow

The following describes the research workflow adopted in this study with intention to develop a generic framework for Malaysian IT SMEs companies to embark on Six Sigma initiatives driving towards the directive of quality control and quality assurance:

A) **Phase 1: Literature review and survey research**. A rigorous review related to different adopted QIMs in the field of IT and non-IT was carried out to understand each QIM's strengths, benefits, criticisms, challenges, causes of failure, implementation cost and duration, primary and secondary effects etc. Besides, a comprehensive literature reviews of Six Sigma discussing its history, concept, logic, calculation, methodology, tools and techniques etc. was achieved; and the Six Sigma case study approach of "The Six Sigma Way" by Pande at al., [152] was explored, discussed and adopted in this study.

The extracted literature information and collected data from survey research allowed the creation of a roadmap of QIM for IT and non-IT related business, the evolution of QIM in Malaysia's IT industry, the resistance factors to QIM implementation; as well as the trend and directives of QIMs adoption in the Malaysian IT companies. The mentioned research efforts were carried out in Year-1 of this research study and the findings of each outcome were published in conference proceedings and journal publication [13, 80, 137, 147].

B) **Phase 2: Exploratory Case Study using "The Six Sigma Way"**. The concept, model, tools and techniques of Six Sigma are applied to a case company IS Support department (UNMC) to understand current helpdesk and front desk operation routines for improvement and to better utilize the full potential of HMS in real-time business analysis and management decision making. An extensive method of quantitative and qualitative was applied to troubleshoot problems and investigation of root cause for improvement was carried out and discussed in Chapter-6. The significant results obtained from phase-1 and phase-2 were gathered and compiled for the development of framework via a mixed method approach and collected data are analyzed prior to developing the framework.

C) **Phase 3: Conceptualize and develop a draft Framework**. A draft version of roadmap to Six Sigma framework was conceptualized and developed upon completion of the IS Support (UNMC) case study investigation. A set of relevant criteria of assessment are gathered and compiled based on the extracted literature reviews and case study outcomes from phase-1 and phase-2. This stage involved an in-depth analysis of addressing "what to do" and "how to do" in fact-base format which later outlined into a sequence of steps to be followed for next round Six Sigma investigation and implementation for next case company.

D) **Phase 4: Test, verify, evaluate and revise draft framework.** The draft framework was later applied into SYNDES (i.e. Project-X) and IS Support UNMC (i.e. Control phase for July 2013 data collection) to test and verify its validity, usability and feasibility in QIM adoption. Since SYNDES is grouped under a different business area of IT Product and IT Process, an extension of criteria of assessment was achieved. The framework was iteratively refined to ensure it fits into all IT business. These text-based criteria of assessment was later translated and streamlined into two broad perspectives outlining the criteria of assessment and handling of decision-criteria in graphical representation format to ease of framework understanding. The framework was iteratively refined to ensure it fits into all IT business areas.

E) **Phase 5: Implement and finalize framework**. The refined framework was put into test at Company-C, SYNDES (i.e. Project-Y) and IS Support UNMC (i.e. Control phase for September 2013 data collection) where the criteria of assessment and decision-criteria are tested and verified again. The framework demonstrated how Company-C benefited from Six Sigma implementation especially in identifying root cause for performance gap and tackling business and operational problems. Results were analyzed to further improve the framework by adopting flow-chart, roadmap, question mapping and set of guidelines to ease of decision-criteria process. The finalized framework was a result of parallel tested, verified and implemented by three case companies from the combinations of IT Product, IT Service and IT Process. The development of this framework helps the management to fully understand the real performance of its business and its processes; and what are the key considerations and directions needed to bring its business closer to excellence.

F) **Phase 6**: **Implement framework to IT industry**. It is made to highlight that it was not possible to generalize the final framework to a wider population within the scope of this study. The reason is that a single case study implementation of a IT-based SME company may take up 6-12 months of effort depending on its' sales turn over and number of full time employees; which exceed the permitted duration for this study. Hence, this phase is not included in this study and will be carried out as future research.

4.7 Selection of Cases – Case Companies

According to Kumar [206], the purpose of sampling in qualitative research is designed to gain in-depth knowledge either about a situation, event or episode or about different aspects of an individual or party on the assumption that the individual is typical of the group and will provide insight into the group. However, a number of considerations may influence the selection of a sample [206]: (1) The ease in accessing the potential respondents; (2) The judgement that the person has extensive knowledge about a situation, episode, event or situation of interest and (3) How typical the case is of a category of individuals.

As the aim of qualitative enquiries is to explore diversity; sample size and sampling strategy do not play a significant role in the selection of a sample [206]. In the event if a sample is selected carefully, diversity can be extensively and accurately described on the basis of information obtained even from one individual [206]. In quantitative research data collection, researcher can be guided by his/her judgement as to who is likely to provide the research study with "best", "rich", "complete" and "diverse" information.

Even though the sample size does not play any significant role, this research study has selected three case companies from different combination of IT fields (i.e. IT Processes, IT Products and IT Services) to ensure the spread of diversity of research boundary is achieved and fulfilled. In order to ensure the case companies selection is representative of the population from the three business areas of IT industry, other methods of qualitative and quantitative data collection were selected (Section 4.8 Data Collection Method). This will give a complete picture of the framework formulation in the Malaysia IT industry.

It may be a concern that the sample size for this study is considered small; the sample size is not the main concern [206] as the purpose of this research is to study a company or few companies in the business areas of IT Services, IT Products and IT Processes to identify its spread of diversity and not its magnitude. Furthermore, the primary limitation is the need to balance the validity, reliability, rich and diverse information against the time and available resources. Collecting data from case companies which covers the research boundary of IT business areas is able to support convincing conclusions. Hence, the sampling strategy used when undertaking this study meets the requirements of qualitative research and the involvement of case companies in different IT-related business areas are summarized below:

- SYNDES Technology (IT Product and IT Process)
- IS Support UNMC (IT Service and IT Process)
- Company–C (IT Service and IT Process)

4.8 Data Collection Methods

In view of the adopted exploratory case study approach in data collection from three case companies of different background and business natures, the author has considered the use of both qualitative and quantitative approach for this study. The qualitative data collection process is characterized by an intensive, detailed study involving collection of large quantities of data from a small numbers of informants and settings; while the quantitative research applies the principles of representativeness and generalizability based on relevance to the theoretical focus of the research [207]. The types of data collection method engaged in this study are discussed in the following section.

4.8.1 Interview

In the attempt to understand the business nature, business activities and business-operational procedures of the three case companies from different IT business areas, qualitative research interview were conducted. It is a means to seek, describe, and elicit information, beliefs or opinions from another person [206]. Interviewing is a commonly used method of collecting information from people as well as from a personal contact between an interviewer and a respondent [208]. The objective of conducting interviews with the case companies' staff of different operational-levels is to enable the research team to maximize understanding of the case companies' background, business work flow, business operational activities, rules and regulations, processes and procedures in day-to-day business routines; at the same time to collect in-depth and detailed information on a range of factors related to the research question(s) and objectives of the research study.

There are a number of different descriptions of quality interviews by a number of researchers (Table 37) which has led to different categorization of interview types, forms and typologies based on its level of structured situation, formality, flexibility and specificity. Each types of interview serve a different purpose. Structured or standardized interviews are used in survey research; while semi-structured or guided interview or free story interview or unstructured interview is used in qualitative research [209]. According to Saunders et al. [210], the methods of semi-structured interviews and in-depth interviews are generally used in exploratory case study approach to capture the viewpoints of the respondents rather than the concerns of the researchers.

Table 37 Types of Interviews

Author	Types of Interviews
Miller and Salkind [208]	• Structured Interview • Focus Interview • Free Story
Kumar [206], **Oliver** [211]	• Unstructured Interviews • Structured Interviews
Litchman [209]	• Structured or Standardized Interview • Semi-Structured or Guided Interview • Unstructured or In-Depth Interview
Myers and Newman [212]	• Structured Interview • Unstructured Interview • Group Interview

Source: Research analysis compilation

In this exploratory case study, a semi-structured or guided interview is adopted where a list of questions are prepared beforehand (Appendix B) to better understand the case companies' day-to-day operational activities. In view of the case companies originate from different IT business areas (i.e. IT Services, IT Products and IT Processes), the attention of the interview questions focuses on: (1) The company background; (2) Business-related activities and operation; (3) Pattern of quality improvement methodology adoption and (4) Project Management related activities (i.e. Project Performance).

4.8.1.1 Design of Semi-Structured Interview Questions

Although conducting an interview takes a considerable amount of planning and experience; the effort of designing semi-structured interview questions takes quite a bit of forethought too. Most importantly, the questions should drive the research questions. In order to achieve this, the research team focuses the development of interviewing techniques in "types of questions" and "questioning strategies". Marilyn [209] has discussed five types of interviewing questions and the details are summarized in Table 38: (1) Grand Tour; (2) Concrete Questions; (3) Comparison/Contrast; (4) New Elements/Topics and (5) Closing.

Table 38 Types of Interview Questions

Types of Question [209]	Description [209]	Application of Question in the research study
Grand Tour	• To explain a series of events or describe oneself in detail • Question is meant to be very general and to encourage the respondent to talk at length	• To find out the general business-**related activities and operations of case companies**
Concrete Questions	• To give an opportunity to be concrete and specific and provide relevant information • To ask for specific story, experience, incident and result rather than a general statement	• To find out if QIM is adopted formally or informally • To find out if adopted QIM uniformly implemented to all business activities or selected business activities only
Comparison / Contrast	• To challenge the participant to think about other times, situations, places, events, or people and draw meaningful comparisons between them	• To draw comparisons of project performances in the context of IT project management • To draw comparison of project scenarios and project events (pre and post) of business activities

Types of Question [209]	Description [209]	Application of Question in the research study
New Elements /Topics	• Shifting to a new topic must be done in a very subtle manner • To cover areas that may not have been considered in previous questions • Normally use "why" and "how" questions for completeness	• To draw attention of the participant to respective case companies' QIM implementation and adoption
Closing	• To provide a chance for the participant to add anything else that has not been mentioned • Normally is used to understand what the participant think and how he/she feel about the discussion topic.	• To summarized the high-level understanding of information gathered during the interview

Source: Research analysis compilation

Typically, this study began with the ethnographic interviewing (i.e. grand tour question) where a set of very general questions regarding the business-related activities, day-to-day operations and project management related activities were asked to encourage case companies to explain respective business intent in detail to aid the preliminary analysis process. Various matrix combinations (Table 38) of concrete questions, comparison/contrast questions and new elements/topic were conducted in the semi-structured interview to derive informative facts and findings prior implementing or integrating Six Sigma DMAIC or DFSS methodology into the case companies to determine and identify root causes of problems.

In view of the uniqueness of Six Sigma approach, the overall high-level business work flow and business operations of case companies are recorded, summarized, compiled and transformed into different forms of pictorial, tabular, graphical, diagram and chart representation using various Six Sigma tools and techniques (i.e. Identification of Core Processes, Support Processes and Key Customer; Supplier-Input-Process-Output-Customer (SIPOC); High-Level Process Mapping; Input-Process-Variable diagram; Cause-and-Effect diagram; Failure Modes and Effects Analysis and Flow Chart) in different phases of Six Sigma (i.e. DMAIC and DFSS). Table 39 summarized the mapping of result interpretation from semi-structured interview into various phase of Define, Measure, Analyze, Improve and Control. The detail interpretations of interview outcomes are discussed in respective case company's chapter (i.e. Chapter 5, 6 and 7).

Table 39 Mapping of Interview Outcomes Using Tools and Techniques of Six Sigma

Component of Interview question	Six Sigma Phases				
	Define	Measure	Analyze	Improve	Control
Company Background	• Identification of Core Processes, Support Processes and Key Customer • Chart • Diagram	N/A	N/A	N/A	• Charts • Graphs • Diagram
Business-related Activities and Operations	• Identification of Core Processes, Support Processes and Key Customer • SIPOC • Chart • Diagram	• Charts • Graphs • Diagram	• High-Level Process Mapping • Input-Process-Variable diagram • Cause-and-Effect diagram • Failure Modes and Effects Analysis • Flow Chart	• Charts • Graphs • Diagram	• Charts • Graphs • Diagram
Pattern of Quality Improvement Methodology (QIM)	• Identification of Core Processes, Support Processes and Key Customer • Diagram	• Charts • Graphs • Diagram	• Cause-and-Effect diagram • Failure Modes and Effects Analysis • Flow Chart	• Charts • Graphs • Diagram	• Charts • Graphs • Diagram
Project	• Charts	• Charts	• Cause-and-Effect diagram	• Charts	• Charts

Component of Interview question	Six Sigma Phases				
	Define	Measure	Analyze	Improve	Control
Management Related Activities – Project Performance	• Diagram	• Graphs • Diagram	• Failure Modes and Effects Analysis • Flow Chart	• Graphs • Diagram	• Graphs • Diagram

Source: Research analysis compilation

4.8.1.2 Strategies for Questioning

Despite the importance of designing the right types of questions for the interview success, the questioning strategies are also critical. If various types of questioning strategies are planned and used correctly, meaningful information can be achieved; and at the same time superficial and glib responses can be avoided [209]. Most importantly, questioning strategies are capable of leading and directing the participant to expand his/her ideas and delve deeper into an event, experience, incident, situation and topic of discussion so that the true underlying meaning is revealed [209]. Table 40 summarized different strategies for questioning applied in this study and its corresponding objective.

Table 40 Strategies of Interview Questioning

Types of Strategies [209]	Description [209]	Application of Question in the research study
Elaboration	Expand ideas	To provide opportunity for the participant to say more or to clarify and elaborate on the overall company background , business-related activities and operations, patterns of QIM and performance of project management
Probing	Elicit more information; delve deeper	To restating by emphasizing on digging down deeper into underlying meaning of feedback or answer gathered during the interview especially in the topics of patterns of QIM and performance of project management
Using Stimuli	Using external enhancers	N/A
Neutrality	Maintain non-directionality	To put both the interviewer and interviewee in a neutral position about Six Sigma as a QIM in the IT industry
Single Question	Only one	To ask one question at a time.
Wait Time	Silence; pauses	Allow pauses between interview to give sufficient time to the participant to think and to respond the question.
Special Areas of Concern	Listen; don't assume	To share the success stories, advantages, disadvantages, myths and demystified facts about Six Sigma

Source: Research analysis compilation

In this study, the interview questions were designed based on open-ended questions and a combination of different questioning strategies (Table 40) in order to elicit more opinions from the respondents on their collaborative experiences. Hence, a combination of different questions types and different questioning strategies were used in designing the interview questions for this study. However, "leading questions", "complex questions", "double-barrelled questions", "questions with jargon or technical language" and "chattiness" should be avoided so that valuable and representative information can be presented.

4.8.2 Ethnography and Observation

Ethnography is a method of qualitative study through the observation of the company, cultures and customs [207]. The ethnographer does not just observe and record the unusual or "extreme" behaviour, but joins in with the everyday activities and life of those who are being studied.

Observation is one way to collect primary data and it is a purposeful, systematic and selective way of watching and listening to an interaction or phenomenon of occurring groups in many different settings (i.e. formal and informal) [206, 209]. It is about observing humans in natural settings assists the understanding of the complexity of human behaviour and interrelationships among groups [209]. Many of the techniques and strategies related to observations originated from ethnographies [209].

The two main research methods associated with ethnography is participant observation and non-participant observation. Participant observation involves the researcher in becoming part of a group or situation that is being studied, in the same manner as its members, with or without their knowledge that they are being observed [206, 209]. On the other hand at non-participant observation, the researcher does not get involved in the activities of the group but remains a passive observer, watching and listening to its activities and drawing conclusions from the observation [206].

In this study, both participant observation and non-participant observation were conducted at the case companies at different phases of Six Sigma life cycle to learn about the interaction in a group (i.e. SYNDES (tester, project leader, project manager, technical lead, business analyst and QA executive), IS Support UNMC (front desk executive, helpdesk support executive and IS Support members) and Company-C (helpdesk support executive, engineer, lead engineer, supervisors)) to ascertain the functions (i.e. day-to-day routines, business operations, QIM-related activities etc.) are performed by worker, and study the behaviour or personality or group traits of an individual or a department. Participant observations are conducted in the "Analyze" phase where individual behaviour as well as departmental norm or culture can be observed; whereas non-participant observations are conducted in the "Improve" phase to ascertain the list of proposed Six Sigma improvement(s) are perform by the staff. The outcomes of observations for case companies are discussed in Chapter 5, 6 and 7.

4.8.3 Questionnaire

A questionnaire is a quantitative research method consist of a series of written questions for the purpose of gathering information from a pool of respondents [206]. This means of gathering information is very popular because it promises to secure data from large population at a minimum expenditure of time and expense. Most importantly, a greater sampling distribution can be achieved (i.e. general population, unique population etc.) via different methods of administering a questionnaire. The selection of a particular method of questionnaire administration depends upon the ease in assessing respondent population; as well as the researcher impression about how a participant would prefer to participant in a questionnaire [208].

Kumar [206] has openly discussed various ways in which the researcher can administer a questionnaire through mailed questionnaire, collective administration, online questionnaire and administration in a public place. Online questionnaires are made in a program for creating web-interviews. The online questionnaire program allows pictures, audio and video clips to be included into the questionnaire to provide better interactive effects to aid of better understanding to respondents. The program also allows customization of questionnaire flow (i.e. question routing, quota sampling, logic routing etc.) based on the answers provided, as well as information already known about the participant. With the advancement in communication technology, the use of online questionnaire to collect information from participants of different background, age group, salary scale, industry, gender etc. has become quite popular and common among the IT industry.

The design of an online questionnaire has a dramatic effect on the quality of data gathered. There are many factors for consideration (i.e. guidelines, available question formats, administration, quality and ethical issues) when designing an online questionnaire. Questionnaires design and construction take a great deal of time and effort, but when designed and administered correctly, they produce a significant and accurate assessment [208]. Following are the adopted steps in this study for questionnaires design and construction:

- *Reclarity the relationship of the method to the problem and hypotheses* [208]. The author determines the objectives and what information needs to be gathered. This involved a thorough thinking of the area to be studied and a clear understanding of the nature of the data needed.
- *Formulate the questions* [208]. The questions for questionnaire should be created in the most appropriate type of format that facilitates understanding such as “introduce yourself and the institution you represent” , “describe the main objectives of the study”, “convey any general instruction (if any)”, “indicate that the questionnaire participation is voluntary”, “assure respondents of the anonymity of the information provided by respondents”, “give a return address for the questionnaire and a deadline for its return” and lastly “thank the respondents for their participation in the study” [206]. Others points taken into account when building the questionnaire are: “Group the questions into different sections to ease of understanding”, “use clear, succinct, appropriate and relevant wording when framing questions”, “choose appropriate question types (refer to Table 30) to avoid confusion”, “allows allowing for a range of answers (open-ended) as well as suggest all possible alternatives to the respondents (close-ended)”, “avoid long questions” and “avoid biased or leading questions”.
- *Organize the questionnaire* [208]. The order in which sections or questions are asked is very important. Always start with easy questions that the respondent will enjoy answering. The flow of topics and questions should be arranged so that they make the most sense to the respondent.
- *Pretest the questionnaire* [208]. Never omit pretesting as this is an essential step in quality control for data collection process. Select and run the online questionnaire with a number of representative respondents. Capture and rectify any misunderstanding, ambiguity and defensiveness by restating the affected questions.

There are a total of two questionnaires (i.e. Appendix-1 and Appendix-4) conducted in this study. The first questionnaire (Appendix-1) is an online questionnaire to gain understanding of patterns, information and knowledge of quality improvement methodologies among the SMEs in Malaysia IT industry. This questionnaire was designed through the “Survey Monkey” platform using the UNMC account (no longer valid); and data are collected and analyzed through the “Survey Monkey” reporting module. The details and finding outcomes of this questionnaire are discussed in Section 2.2. The second online questionnaire (Appendix-4) was designed and conducted via “Lime Survey” program (http://survey.nottingham.edu.my/admin/admin.php). This is an online assessment questionnaire of case company’s project management maturity level as well as level of project management excellence. The details and summary of the collected data are discussed in Section 8.6.

4.8.4 Archival Information

In addition to gathering data using interviews, observations and questionnaires; there are other excellent sources of qualitative information. “Written Word’ or “Archival Information” is documentation of the watchwords of historical information and these are the evidence of what people did, said, thought, performed, executed in the past [209]. Archival information appears in the form of records, emails, management reports, project-related documents etc. The existence of such written materials within an organization is so important that it allows the researcher to develop field notes in connection after an extensive observation to express his/her thoughts on a particular challenging aspect of the research topic. This method of data gathering challenges the researcher to find the underlying meanings as well as reveal what is beneath the surface meaning from this archival information [209].

This collection of written data in this research study is a challenge task as it involved “what to collect”, “what to do with it” and “how to use these raw data to answer the research questions”. The listing of sources for archival information used in the case companies are summarized in Table 41 and the interpretation of these “written words” are discussed and explained in Chapter 5, 6 and 7.

Table 41 Sources of Archival Information

Case Company	Sources of Archival Information
SYNDES Technologies	Existing Project Life Cycle Model, Project Related documents (i.e. Project Schedule, Bug Lists, Project User Checklists, User Acceptance Test Plan, Unit Testing Plan, System Requirement Specification, System Specification, Functional Test Plan, Code Walk Through List, Project Implementation Guideline.
IS Support UNMC	Helpdesk Management System records, Students Survey results, IS Support and Helpdesk Operation Guidelines, IS Support Services Guidelines, IS Support UNMC work flow, Educational Management System records and IS Support forms
Company-C	Company Work Flow, Break-fix Work Flow, Data and records for project accounts (history and present), Helpdesk System records, Job Sheet, Ticket-Engineer Assignment records, Project Account Performance reports and Engineer Performance records

Source: Research analysis compilation

4.9 Ethical Issues, Ethical Considerations and Ethical Protocols

In addition to conceptualizing the Six Sigma framework for implementation and integration in Malaysia's SMEs IT companies, it is important to anticipate and consider the code of ethics which governs the way this research study was carried out. Ethics can be broadly defined as 'do good and avoid evil" and it represents a set of moral principles, rules, or standards governing a person or a profession [209]. Kumar [206] defines "ethics" as "in accordance with principles of conduct that are considered correct, especially for those of a given profession or group". However in the context of this study, ethics refer to the appropriateness of the researcher's behaviour in relation to the rights of those who become the subject of work, or are affected by it [210]. The key phrases of "principles of conduct" and "considered correct" raise certain questions and arguments particularly researchers' need to protect their participants; develop a trust with them; promote the integrity of research; guard against misconduct and impropriety that might reflect on their organizations or institutions; and cope with new challenging problems [188].

Each category of stakeholders in research activity may have different interests, perspectives, purposes, aims and motivations that could affect the way in which the research activity is carried out and the way results are communicated and used. Hence, it is important to ensure that research is not affected by the self-interest of any party and is not carried out in a way that harms any party [206]. It is therefore essential to examine ethical conduct in research concerning different stakeholders under separate categories of [206]: (1) Ethical issues concerning research participants; (2) Ethical issues concerning the researcher; (3) Ethical issues concerning sponsoring organization and (4) Ethical issues in collecting data.

There are many ethical issues to consider in relation to different stakeholders and following are adopted ethical principals in this study:

1) Ethical issues concerning research participants

- To consider and justify the relevance and usefulness of the undertaking research [206]
- To safeguard against doing anything that will harm the participants (i.e. to discontinue the study if adverse reaction is detected) [206, 209]
- To seek informed consent from the participant to greatest extent possible about the nature of the study; the consent should be voluntary and without pressure of any kind [206]
- To remove identifying information from the records, seek permission if researcher wish to make public on sensitive information [206, 209]
- To protect the confidentiality and anonymity of the information gathered from respondents [206, 209]

2) Ethical issues concerning to the researcher

- To avoid bias [206]
- To use appropriate methodology, within his/her knowledge base when conducting a study [206]

- To produce correct and unbiased reporting of the findings [206]; avoid create data or fudge data [209]
- To provide an environment that is trustworthy; avoid setting up a "friend-researcher" situation [206]

3) Ethical issues concerning sponsoring organization

- Beware of direct or indirect controls or restrictions imposed by the sponsoring organization [209] such as revealing clients' information, using the company name as reference etc.
- To avoid sponsoring organization uses research platform as a pretext for promoting management's agenda

4) Ethical issues in collecting data

- To present data in the same format and context [206]
- To present evidence when interpreting data [206, 209]
- To avoid disclosing data sources unless consent is given or granted [206]
- To guard against sharing of data with individuals not involved in the study [188]
- To keep analyzed data for a reasonable period of time (i.e. recommends 5-10 years) [188]
- To protect participants' rights during data collection [188]

It is useful and important to consider and be aware of ethical issues that can be anticipated at all phases of the research process when conducting research. Therefore, the ethical principles and considerations outlined in the above have been followed in this study to ensure the research is in compliance with the university and best practice ethical standards.

4.10 Chapter Summary

It is important to examine a study method and data from different viewpoints to ensure a comprehensive approach to research questions is achieved. As a result, researcher needs to have good understanding about different types of research method, its aims, strengths, limitations as well as its boundary prior deciding on any research method. A careful investigation or inquiry especially searching for new facts and knowledge is crucial to ensure a phenomenon can be correctly measured within the limits of time, money, feasibility, ethics and availability.

The selection of the research method affects and influences the outcomes of the phenomenon. If any research method is inappropriately used or poorly used; the result of a study could be misleading and wrong conclusions will be drawn which affects and influence the cause and factors of the phenomenon. There is no one formula for developing a successful study, but it is important to realize that the research process is an iterative cycle. This study cannot shy away from understanding research as it has to deal with different type of cases which may not be straight forward; and having a good foundation of research helps to generate measurable and testable data which further leads to development of a valid, reliable and generalized framework of Six Sigma implementation and integration in the Malaysia SMEs IT industry.

Chapter-5 Case Study: SYNDES Technologies

5.1 Company Background

5.1.1 Introduction

SYNDES TECHNOLOGIES Sdn Bhd is an independent provider of network and data management tools and services. SYNDES is a software services and consulting company that offers the core benefits of knowledge, technology and best practices in the capacity of a solution provider. SYNDES focus on defining, optimizing and aligning our client's business strategy with IT initiatives. Apart from a wide network across Malaysia, SYNDES also has a significant international presence in Asia Pacific such as Singapore, Indonesia and Philippines as our prestigious clients. In align with the objectives of Multimedia Super Corridor (MSC) and to further strengthening its commitment, SYNDES is one of the beneficial start-ups under Microsoft BizSpark Program and Microsoft Registered Members. In Malaysia, SMEs are defined by two key variables which are (i) based on the number of annual sales turnover or (ii) full time employees [213, 214]. SYNDES falls into the category of “Small Enterprise” in the ICT sector with annual sales turnover between RM200,000 and less than RM1 million IOR full time employees between 5-19.

5.1.2 Business Intent and Organization Chart

SYNDES growth strategy is aimed at the global client, ranging state-of-the-art business-to-business (B2B) and business-to-customer (B2C) applications, to enterprise workflow applications. SYNDES enables designing processes, business models and partnering mechanisms to transform the organization to leverage business opportunities. It thus has resulted in providing the impetus for pursuing its growth plans aggressively. SYNDES strives to assist clients to build robust business architectures, reliable and scalable infrastructures that meet the mission of clients' critical systems.

SYNDES is a resource-scarce SMEs and it is currently adopting the hierarchical organizations structure with higher ranking individuals situated atop the chart and lower ranking persons found below them (Figure 9). The organizational chart clearly outlines the roles, responsibilities and relationships between individuals within SYNDES. This is the most commonly adopted organizational chart in most SMEs.

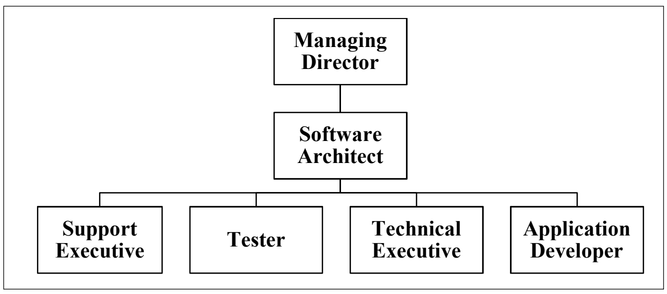


Figure 9 The Organization Chart of SYNDES Technologies

5.1.3 Technology and Product Development Strategy

SYNDES creates and implements Intranet and Internet-based business solutions that improve mobile network and operational performance, facilitate collaboration among managements, engineers, and customers. SYNDES employs some of the industry's leading client strategists, software developers, graphic designers, professional and project managers to create technology which work well for IT Solution Provider Company. The major business areas of SYNDES are focusing on "IT Products", "IT Services" and "IT Support" as shown in Table 42:

Table 42 Business Area – SYNDES Technologies

Business Area	Type of Business	Business Activities
IT Products	**WiMAX Network Performance Analyzer**	(i) Remote (Offline) viewing KPI Performance Analysis ▪ RNC / NAC Performance ▪ NodeB / WBS / Cell Performance ▪ Top Best / Worst Cell Performance (ii) Customer Complains Support ▪ Troubleshoot network based on different level of Performance Indicator (PI) (iii) Multi-Dimensional Metrics Analysis ▪ Facilities with Customer Complains Support ▪ Answerable Customer Complains
	K2[blackpearl]	• Process driven application • Automates business process with visual tool • Foster business and technical users collaboration • Sophisticated workflow
IT Services	**Application Development**	Focus on defining, optimizing and aligning our client's business strategy with IT initiatives. SYNDES undertake all kind of web based software development, mainly in Microsoft and Open Source Technologies.
	Business Consultancy	Offer complete IT Business Consultancy related to Business Alignment, Project Management, System Architecture, and Solution Engineer
	Support Services	Offer complete implementation, support and custom enhancements services in various aspects.
IT Support	**Customer Support**	• Administer technology accelerators to enhance and improve workflow. Leveraging on economies of scale and best practices. Simplifying, standardizing and streamlining processes. • Establish stable and dependable end-to-end networking and infrastructure solutions. Offer network outsourcing and nationwide maintenance support services option to allow our customers to focus on their core business. • Remote hosted application services to cater for clients' various needs. Benefiting our customers with cost reduction through demand aggregation and reduction of processing and administration costs.
	Special Support	Manage, Share and Deliver Critical Network Reports. Retrieve switch dump files from the OSS and parse them automatically. Support network performance reporting for engineers and managers.

Source: Case study analysis compilation

5.1.4 The IT Projects for SYNDES Technologies

For the past three years, SYNDES has completed a few projects covering various areas of technology and Table 43 is the summary of SYNDES's projects:

Table 43 IT Projects Listings in SYNDES

No	Project	Description
1.	**Human Resource Management System (HRMS)**	A human resource management system is a software program or suite of programs for managing business processes related to human capital management (HCM). Such systems can be as simple as a database and associated database management system (DBMS), or it can as complicated as a suite of customized software that intersects between human resource management (HRM) and information technology.
2.	**Fleet Management System (FLM)**	FLM is a vehicle tracking and fleet management system where the project is embarking on a robust and flexible solution to address new and easy maintenance of Vehicle Management system (VMS).
3.	**Fine-Tuning GPRS Server Application Performance**	A GPRS connection which is common among GSM mobile phones can be used to share data globally. As more and more devices and gadgets are tapped on server, the respective FPRS performance may deteriorates. Most counties have a weak GPRS speed in their carriers, therefore fine-tuning the performance of GPRS Server is necessary as there is an observed increase in connectivity.
4.	**Geo Fencing / Geo Location Feature**	A **geo-fence** is a virtual perimeter for a real-world geographic area. Geo-fencing in a security strategy model that provides security to wireless local area networks. This is done by using predefined borders, e.g., an office space with borders established by positioning technology

No	Project	Description
		attached to a specially programmed server. The office space becomes an authorized location for designated users and wireless mobile devices [215].
5.	**Pregnancy Journey Portal**	It is a content management portal about health and wellness categorized as "For Mum", "For Dad" and "For Child". It provides pregnancy guide for the mum-to-be, nutrition guide, pregnancy health recipe, calendar tracking of pregnancy etc. It is a "one-stop" portal where a mum-to-be would find it helpful and informative from fertilization to development of one or more offspring
6.	**WiMAX Performance Optimization & Statistical Tool - WiMAX**	It is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gbit/s for fixed stations. It aims to improve the reception and allows for a better reach and rate of transmission which would result in lower interference and improve performance in spectral efficiency.
	WiMAX Network Coverage Toolkit	It is something nice to have and this toolkit is a goodwill as part of the WiMax Network Coverage Optimization project.
	WiMAX Network Coverage Optimization	It aims to expand WiMAX network coverage covering more designated WiMax base stations to achieve resource optimization.

Source: Case study analysis compilation

5.2 Define Phase

5.2.1 Introduction

Producing IT products and IT services required careful design. IT development process is intangible and labour intensive. Making optimal use of available resources, both soft (knowledge, skill-set etc.) and hard (computer system, ancillary equipment etc.), is vital if IT development is to achieve sensible economic advantages [38].

The scope of activities in the Define phase is to analyze, investigate, measure and improve the IT operational processes (i.e. Project Management methodology) for SYNDES to minimize redundancy, rework, budget overrun and schedule slippage for upcoming IT projects. It aims to find out the mistakes, risks and lessons learnt from the past completed projects; and to explore potential improvement opportunities for next up-coming project.

A preliminary analysis on the IT project management procedure and process flow activities were collected via semi-structured interview. The initial understanding of SYNDES operational process flow kicked start with interviewing the following IT personnel:

- Ms. Jen Yong, Managing Director of SYNDES. Jen Yong is responsible for overall marketing, operational, quality assurance and any company-wide activities related to SYNDES.
- Ms. Miki Lai, a Software Architect to SYNDES. Miki Lai oversees all aspects of software quality assurance within SYNDES.

5.2.2 Summary Of Interviews

5.2.2.1 Managing Director

The author scheduled a meeting with Ms. Jen on 7th September 2012 and it kick started with sharing the research objective to explore opportunities using SYNDES IT Projects as the Six Sigma case study project. The author explained how Six Sigma has been well received by many IT organizations as a quality improvement initiative into company level activities for process improvements as well as improves customer satisfaction. At the same time, review listings about success stories of Six Sigma implementation in different business areas of IT Services, IT

Processes and IT Products was shared to Ms. Jen. Furthermore, the author clarified doubts about the common myths of Six Sigma being expensive and that it only works for large scale organizations.

SYNDES does not adopt any formal quality improvement initiative, except with an informal ITIL (initially) and Software Quality System (SQS-1 version 4.1 by Jan 2014) methodology. Jen Yong entrust QIM as she believes that nothing will be in place without a proper systematic and top down approach of operation guidelines. SYNDES is adopting an operation framework where different resources are assigned to different phases throughout the project life cycle. This framework was implemented to most IT projects.

Next, Jen Yong shared her lessons learned from all past IT projects and expanded her views on some DO's and DON'Ts in IT industry. After three hours of sharing, following are the summary of SYNDES' IT projects concluded from the meeting:

- Majority of the past IT projects do not deliver on time. Despite proper planning, cost overrun, rework, scope creep and bugs after bugs are the common challenges SYNDES been facing.
- The research team is not sure about the true root-cause to these challenges; it could be a people issue, skill-set issue, or caused by over-demanding clients. Jen Yong would like to further understand the root-cause of these challenges which always deter the team from on-time delivery. She opted to find out the root-cause and no more guessing.
- Since there are multiple projects running simultaneous over the years, there is no significant effort taken to investigate the root-cause and has no predetermined solution for the challenges have been identified.

The information and details of completed existing IT projects work flow have helped to justify the potential of IT projects in the case company as a Six Sigma case study improvement project: (1) There exist performance gaps between planned/scheduled and actual IT project management activities; such as scope, user requirements, timeline, costing etc. ; (2) The reasons of deficiency in IT project management activities were not clearly understood and the real root-causes must be identified ; (3) To-date, there is no significant effort being launched to bridge the "gap" and currently there isn't a predetermined solution or the optimal solution is not apparent.

5.2.2.2 Software Architect

An interview with Miki Lai took placed after office hour on 13th September 2012. Despite being the most senior technical executive in SYNDES, she is wearing the hat of "Quality Assurance (QA)" for all SYNDES' projects. It is the routine for Miki Lai to undergo QA role prior releasing any project. The time taken for QA task could take up to five days depending on the severity of source code discrepancy and database structure discrepancy which deter future enhancement and maintenance. This is the moment where everyone is under stress to push the software out of the door. Miki Lai always wanting to reduce QA effort prior release but it has never happen.

Miki Lai views SYNDES is a “young and potential” company where great emphasis is needed on managing delivery quality by focusing and directing its available scarce resources, money and time on quality management methodology and framework which drives operational excellence. She believes that the company’s products and services will enhance only if a proper quality system is in place. Miki Lai hope that Six Sigma approach will bring value-added changes to SYNDES operational procedure for future management.

5.2.3 Identification of Core Processes, Support Processes and Key Customers

The team categorized the core processes of SYNDES into IT Product Development; IT Service Development; IT Support Development; WiMax (Worldwide Interoperability for Microwave Access) Network Related Performance Analyzer; Application Development and Business Consultancy; and Customer/Special Support. In general, the core processes for SYNDES is IT product, service development and supply which involve conception, analysis, design, coding, testing, training and deploying of new value-added customized product and service to customers. The standard processes that provides key resources or capabilities that enable the core processes (IT product, IT service development and supply) to perform are the support processes.

Since the business nature of SYNDES is heavily resource-driven and IT-focused, the support processes rely heavily on human resources (developer, technical staff, business lead, technical lead, project leader, project manager etc.), hardware and software (i.e. internal or external), IT Infrastructure (i.e. WiFi, WiMAX, Internet Access etc.), Process (formal and informal), QA (formal and informal) as well as finance and strategies in supporting all the core processes.

Source: Case study analysis compilation

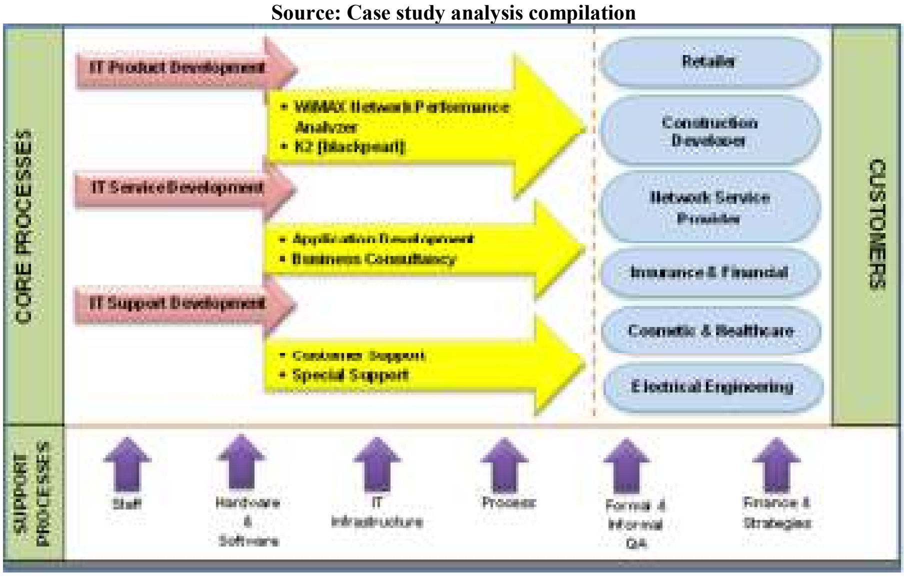


Figure 10 High Level Overview of SYNDES Technologies Core Processes, Support Processes and Key Customers [216]

It is important and necessary to identify the key customers of SYNDES in order to develop appropriate messages and methods to engage them; to implement a plan to foster the business relationship and stay competent among others competitors. Ever since SYNDES has successfully secured its first project in 2009, SYNDES has aggressively expanded its IT business covering various industries. Its key customers are ranging from the retailer chain to construction developer, network service provider, insurance and financial and others which is yet to be disclosed. The overall high-level identification and integration of SYNDES' core processes, support processes and key customers can be summarized in Figure 10.

5.2.4 Overview Of Project Life Cycle: SIPOC Diagram

The "big picture" of the case company's business and cross-functional activities can be described in a broader view of its PLC through the SIPOC diagram as shown in Figure 11. The Project Life Cycle refers to a logical sequence of activities to accomplish the project's goals or objectives [31]. Regardless of scope or complexity, all projects go through a series of stages during its life. The details of each phase are explained in section 8.1 of the Synthesis Summary chapter.

Source: Case study analysis compilation

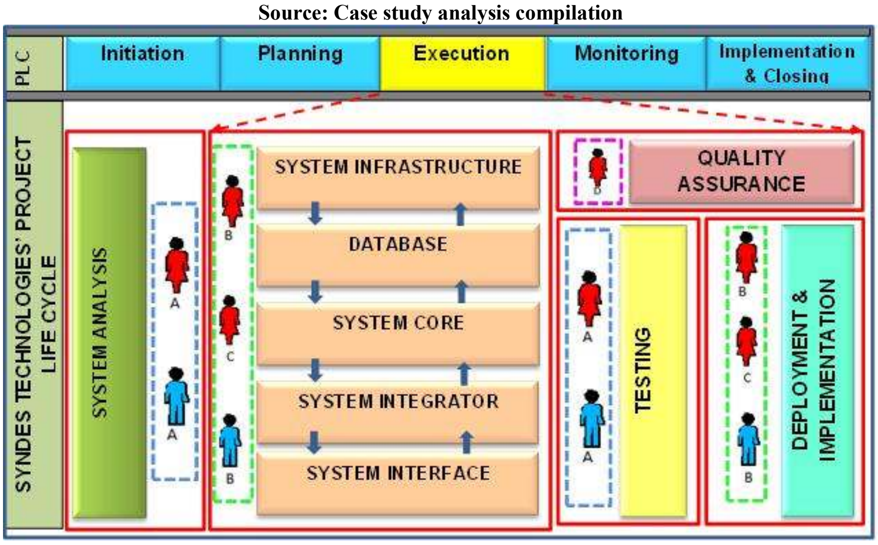


Figure 11 The Project Life Cycle of SYNDES Project [216]

The SDLC is a process used by a systems analyst to develop an information system, training, and user (stakeholder) ownership. The SDLC aims to produce a high quality system that meets or exceeds customer expectations, reaches completion within time and cost estimates, works effectively and efficiently in the current and planned Information Technology infrastructure, and is inexpensive to maintain and cost-effective to enhance. Computer systems are complex and often (especially with the recent rise of service-oriented architecture) link multiple traditional systems potentially supplied by different software vendors.

Figure 11 outlined the phases involved in SDLC as part of the PLC. During the Execution phase, the operational activities of SYNDES are (not in a chronological order as it greatly depends on the characteristics and nature of the IT project):

- **System Infrastructure** is responsible for designing and analysis of infrastructure consisting of infrastructure setup and as a solution provider covering virtualization, failover and etc.
- **Database** constitutes of database designing and planning where stored procedure are produced, creating SQL jobs and etc.
- **System Core** is the heart of the system where system framework is designed and developed
- **System Integrator** is the building hub of business logics. This is the place where business logic and user interface are integration under a single system platform.
- **System Interface** is a critical phase for testing user friendliness. A user interface layout template will be designed and developed.

SIPOC is a handy technique and is a big help in getting people to see the "broader and big picture" of business flow from a process perspective, to which additional detail can be added. SIPOC displays a cross-functional set of activities in a single, simple diagram. It uses a framework applicable to processes of all sizes either for selected departmental process flow or for the entire organization. SIPOC diagram for SYNDES is outlined in Figure 12, the next step is to define the CTQs characteristics and issues, VOC, the potential improvement opportunities, and important quality measures and expectation [11, 36, 115]. SYNDES's projects are skewing towards "process and product quality" as its CTQs.

5.2.5 Identification of Critical-To-Quality and Voice-Of-Customer

The next step is to identify Critical-To-Quality (CTQs) (Table 44) to ensure acceptable performance standards can be met in satisfying customers' needs. The preliminary investigation revealed that the case company is experiencing an inefficient and ineffective time-cost budgeting in IT project management activities. Majority of the IT projects were completed behind schedule, over-budget, requiring repetitive effort and significant scope creep:

Table 44 CTQs for SYNDES Technologies

No	Defections	CTQs
1.	Quality defections	• Numbers of reported bugs with different severity impact
2.	SRS defections	• Total changes made to SRS upon product delivery • Consistency quality control, quality assurance and quality management of SRS items • Total SRS items are being tracked, monitored and controlled
3.	Project Documents defections	• Readiness of project document(s) preparation at relevant PLC cycle • Completeness of project document at different PLC cycle • Level of Project Document coverage on system and functionality specification
4.	Delivery defections	• Time taken to deliver the end product and service
5.	QA Testing defections	• Number/Frequency of QA Testing in the PLC • Satisfaction level of QA Testing
6.	Resource utilization	• Maximizing project performance with scared-resources • Resource utilization within the phases of PLC

Source: Case study analysis compilation

Source: Case study analysis compilation

Supplier	Input	Process	Output	Customer	Requirements
Printer	IT knowledge-based resources	Gathering User Requirement	IT Software	Stakeholder	Signed-off SRS
Hardware vendor	Project Schedule	Sign-off System Requirement Specification	IT Hardware	Departmental Head / Manager	Approved Project Schedule
Software vendor	System Request Specification (SRS)	Development of IT Product / Service / Support	IT Service	IT Manager	On time delivery
Internet Service Provider	Software	End Product Delivery	IT Support	End-users	On budget
Telco Companies	Hardware	Sign-off User Acceptance Test (UAT)	System Specification	IT and non-IT SMEs	Fulfilling and Delivering user requirements
Network Infrastructure Supplier	Network	User Training	Functional Specification		Signed-off UAT
	Internet Connection	Implementation	User Guide / User Manual		
	Contract	Maintenance (depend on contract)			

Figure 12 The SIPOC Diagram for SYNDES Technologies [216]

According to Pande at al., [152], the CTQs measures can be posted and grouped into two broad categories of: (i) Output and (ii) Input/Process as shown summarized in Table 45:

Table 45 CTQs Measure for SYNDES Technologies [216]

No	Output Measures		Input/Process Measures
1.	Quality Defect	Quantity of reported bugs by severity level	Total quantity of bugs reported by client after project implementation; accordance to severity level of high, medium and low impact.
2.	On-time Delivery Defects	Numbers of days delay for a project release	Discrepancies between plan and actual product/service/support delivery date.
3.	SRSs Defects	Percentage of changes made to baseline SRS	Discrepancies of user requirements between baseline and delivered product/service/support.
4.	Quality Assurance (QA) Testing Defects	Tracking of QA testing in the SDLC	Existence and frequency of QA testing throughout the project life cycle and SDLC
5.	Project Documents Defects	Production of necessary technical and support docs in the PLC	Existence and completeness of necessary project documents throughout PLC
6.	Resources Allocation Defects	Efficiency and effectiveness of resource allocation	Percentage utilization of project resources allocation

Source: Case study analysis compilation

Once the CTQs are identified, next is to search for underlying reasons for customer dissatisfaction and project-related defection. For example, by identifying the chief contributors of the root-cause (i.e. late delivery, lack of system knowledge, inefficiency of operational work flow and procedure), SYNDES is facing an increase of repetitive effort (i.e. rework, recode, retest etc.). Six Sigma implementation is a long term commitment. A successful Six Sigma effort requires relentless communication and reinforcement from operational level to top management. In order to be successful over long haul, one needs to "Scope projects well and monitor organization culture" [89].

5.3 Measure Phase

5.3.1 Introduction

SYNDES is an IT Service Provider involves heavily in IT product (software) development. Software quality has been the main concern from the case company's VOC as well as from the development team. Therefore, the authors are focusing on factors which affect the outcome of software development and software production for the case company.

Quality has always been a difficult topic to define, and software quality management has been exceptionally difficult [148, 217]. The perception of quality varies from object to object as well as person to person (i.e. clients, developers, end users, project managers, software quality personnel, testers, stakeholders etc.). In short, quality often depends on the context in which a software component or feature operates. Therefore, the case study has focused more on factors which affect the development and production of an acceptable customized IT software product.

The two main processes of measuring current performance are "Plan and execute measures of performance against customer requirements" and "Develop baseline defect measures and identify improvement opportunities". Table 46 is the five-step measurement implementation model suggested by Pande et al., [152] which gives an overview of key questions/actions ask/take at each of these measurement steps. The analysis of this study is deploying to the "Fleet Management System (Phase-I)" project:

Table 46 Application of 5-Steps Measurement Implementation Model for Case Study Company

Step		Question and Answer
Select What To Measure	**Q:**	**What output or service requirement(s) will best help SYNDES gauge performance to customer needs?**
	A:	Software quality and on-time software delivery
Develop Operational Definitions	**Q:**	**How can the team clearly describe the factor that are being tracked or counted?**
	A:	By in-depth understanding of the operational process and activities of gathering user requirement, product development, unit testing, QA testing, document review, code walkthrough etc.
Identify Data Sources(s)	**Q:**	**Where can the team find or observe data to provide the measure?**
	A:	Manually from historical data (from project schedule, user requirement list, reported bugs list, user acceptance test plan, unit test, frequency of QA testing, business knowledge sharing etc), people and the project.
Prepare Collection & Sampling Plan	**Q:**	**What forms or tools are needed to capture and organize data?**
	A:	Forms (defects and cause check-sheets, data sheets), Stratification and Sampling
	Q:	**How many observations or items are required to get an accurate measure?**
	A:	As many as possible
Implement & Refine Measurement	**Q:**	**Can the team test the measures before going into full-fledged implementation?**
	A:	Yes.
	Q:	**How should the team monitor the data gathering process?**
	A:	By observation, tracking and controlling of project plan between "baseline" and "actual" outcome.

Source: Case study analysis compilation

5.3.2 Introduction To Data Collection

A total of eight projects from various areas were taken into consideration in the Six Sigma Measure phase and data measurements are based on the CTQs defined in the Define phase. A comprehensive range of projects were retrieved from various history sources and archives, and the findings of project variables for the eight projects are summarized in Table 47 and Table 48. It can be observed that only Project-C and Project-F spent 20% and 23% respectively on planning, the rest of the projects utilized less than 10% or equivalent of the total project time on planning. As a result, more bugs are captured during the PLC and rework is needed to correct these mistakes. The findings reflected that the case company experienced a lack of planning effort in most projects. Kerzner [218] recognized the importance of up-front planning and the most critical phase of any IT project is the planning phase, where any corrective actions after system implementation cost 20-times more than the initial stage [30]. When a project is planned carefully; success is likely [218], rework is reduced, budget is controlled and scope creep is reduced.

Table 47 The Operational Definition for IT Projects – SYNDES Technologies

Projects / Operational Definition	Human Resource Management System (HRMS) – A Sept 2010 - Present	Web-Trac Revamps % Upgrade (Phase-I) - B Jan 2012 - Present	Fine-Tuning GPRS Server Application Performance – C Apr 2010 – Jun 2010	Geo Fencing / Geo Location Feature - D Dec 2010 – May 2011	Pregnancy Journey Portal - E July 2011 – Dec 2011	WiMAX Performance Optimization & Statistical Tool - F Jan 2011 – Aug 2011	WiMAX Network Coverage Toolkit - G Dec 2009 – Jan 2010	WiMAX Network Coverage Optimization - H Jun 2009 – Jan 2010
Project Duration	16 wks or 80 days, 2 FTE	20 wks or 100 days, 3 FTE	2 wks or 10 days, 2 FTE	8 wks or 40 days, 1 FTE	16 wks or 80 days, 2 FTE	4 wks **or** 20 days, 1 FTE	1 wk or 5 days, 1 FTE	20 wks **or** 100 days, 1 FTE
Changes to baseline SRS	□ 5% - 10% □ 10% - 20% □ 20% - 30% ■ **30% - 40%**	□ 5% - 10% □ 10% - 20% □ 20% - 30% ■ **30% - 40%**	N/A	■ **< 5%** □ 5% - 10% □ 10% - 20% □ 20% - 30%	□ 5% - 10% □ 10% - 20% ■ **20% - 30%** □ 30% - 40%	□ 5% - 10% ■ **10% - 20%** □ 20% - 30% □ 30% - 40%	N/A, it is a toolkit as goodwill to client	■ **5% - 10%** □ 10% - 20% □ 20% - 30% □ 30% - 40%
Project Delivery Status	□ Ahead of time □ On-time ■ **Delay** **6 wks or 30 days, 2 FTE**	□ Ahead of time □ On-time ■ **Delay** **6 wks or 30 days, 3 FTE**	□ Ahead of time ■ **On-time** □ Delay	□ Ahead of time ■ **On-time** □ Delay	□ Ahead of time □ On-time ■ **Delay** **4 wks or 20 days, 2 FTE**	□ Ahead of time □ On-time ■ **Delay** **3 wks or 15 days, 1 FTE**	□ Ahead of time ■ **On-time** □ Delay	□ Ahead of time □ On-time ■ **Delay** **4 wks or 20 days, (1) FTE**
Code Walk Through	■ **Yes, brief** □ No	■ **Yes, brief** □ No	N/A due to project is making changes to existing code	□ Yes ■ **No**	□ Yes ■ **No**	□ Yes ■ **No**	N/A	□ Yes ■ **No**
Frequency/Effort of QA Testing	Expected: **3 times** Actual : **1 time**	Expected : **3 times** Actual : **1 time**	Expected : **3 times** Actual : **1 time** (at client side)	Expected : **3 times** Actual : **1 time** (at client side)	Expected : **3 times** Actual : **1 time**	Expected : **3 times** Actual : **1 time** (at client side)	N/A	Expected : **3 times** Actual : **None**
Existence of Unit Test Plan	□ Yes ■ **No**	□ Yes ■ **No**	□ Yes ■ **No (at client side)**	□ Yes ■ **No (at client side)**	□ Yes ■ **No**	□ Yes ■ **No (at client side)**	□ Yes ■ **No**	□ Yes ■ **No**
Reported Bugs (High, Medium, Low)	N/A, still on going	H : **100** M : **20** L : **9**	N/A	N/A	H : **2** M : **3** L : **6**	N/A	N/A	N/A
Project Review	□ Formally ■ **Informal**	□ Formally ■ **Informal**	□ Formally ■ **Informal**	□ Formally ■ **Informal**	□ Formally ■ **Informal**	■ **Formally** □ Informal	N/A	□ Formally ■ **Informal**

Source: Case study analysis compilation

Table 48 Summary of Variables By Project [216]

Project	Project Description	Baseline Duration (days)	Actual Duration (days)	Planning (days/%)	FTE*	Baseline Changes (%)	Plan Frequency QA Testing	Actual Frequency QA Testing
Project A	Human Resource Management System (HRMS)	80	110	8 (7.4%)	2	40	3	1
Project B	Fleet Management System (Phase-1)	100	130	1 (0.7%)	3	40	3	1
Project C	Fine-Tuning GPRS Server Application Performance	10	10	2 (20%)	2	0	3	1
Project D	Geo Fencing / Geo Location Feature	40	40	2 (5%)	1	5	3	1
Project E	Pregnancy Journey Portal	80	100	5 (5%)	2	30	3	1
Project F	WiMAX Performance Optimization & Statistical Tool	20	35	8 (22.8%)	1	20	3	1
Project G	WiMAX Network Coverage Toolkit	5	5	0.25 (5%)	1	0	0	0
Project H	WiMAX Network Coverage Optimization	100	120	10 (8.3%)	1	10	3	1

*** Note:** FTE – Full time employee **Source: Case study analysis compilation**

As such, Project-B and Project-E are the "typical customized" software where it is anticipated to traverse through the PLC. Project-B, Fleet Management System**s** is about vehicle tracking and fleet management system embarking on a robust and flexible solution to address new and easy maintenance of Vehicle Management System (VMS). A vehicle management system combines the installation of an electronic device in a vehicle, or fleet of vehicles, with purpose-designed computer software at least at one operational base to enable the owner or a third party to track the vehicle's location, collecting data in the process from the field and deliver it to the base of operation. Modern vehicle tracking systems commonly use GPS or GLONASS technology for locating the vehicle, but other types of automatic vehicle location technology can also be used. Vehicle information can be viewed on electronic maps via the Internet or specialized software. VMS is implemented using Microsoft platform integrating with Google Map to provide the advance graphical map functionalities. SYNDES developed a user control platform which leverage on Microsoft and Google Map technologies that provides advanced mapping functionality and is result oriented in vehicle trip tracing and monitoring.

The project of Fleet Management Systems is a project comprising of three phases: (1) Phase-1 Essential Tracking features (Completed); (2) Phase-2 Enhancing mobility and monitoring features (Current); (3) Phase-3 Performance Optimization and additional features (future).

Project-E is a content management Pregnancy Journey Portal proving guidelines on pregnancy cycle and is a "one stop for mum". Though this project is short, it was better managed in terms of quality testing compared to Project-B. Table 49 tabulates the collected data for both project-B and Project-E as a means of comparison between them.

Table 49 Summary of Variables for Project-B and Project-E – SYNDES Technologies

Testing Variables	Project B	Project E
Duration (Days)	100	80
Delays (Days)	30	20
No. of Bug - High	100	2
No. of Bug - Medium	20	3
No. of Bug - Low	9	6
Baseline Changes (%)	40	30
FTE	3	2
Code Walkthrough	No	No
Plan QA Testing	3	3
Actual QA Testing	1	1
FTE Involvement	By Phase	Entire PLC
QA Testing	After Coding Completion	By Phase and Module
Rework (Days)	30	5
Planning (Days)	1	5

Source: Case study analysis compilation

5.3.3 Findings

5.3.3.1 On-time Delivery Defects

Source: Case study analysis compilation

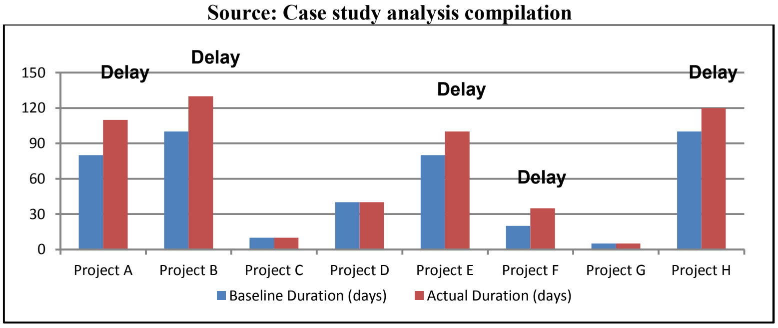


Figure 13 Project Status Delivery By Project – SYNDES Technologies

In the PLC, the actual project timeline is always track against the baseline schedule to ensure project is delivery on-time, within budget and meeting user requirements. A total of eight IT projects were taken to gauge the delivery performance of the case company. The chart of actual project duration (in days) were plotted against its' baseline duration (Figure 13). The data tabulation showed a result of late delivery (delay) in 5 projects out of total 8 projects. In short, Project A, B, E, F and H are delayed and Project C, D and G has the project delivered on-time. The overall project delivery performance for SYNDES is unsatisfactory; observed with 62% chance of project delay against 38% of on-time delivery (Figure 14).

Source: Case study analysis compilation

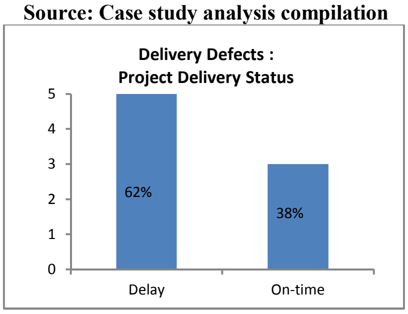


Figure 14 Project Delivery Status – SYNDES Projects (Quantity)

5.3.3.2 Quality Defect

Source: Case study analysis compilation

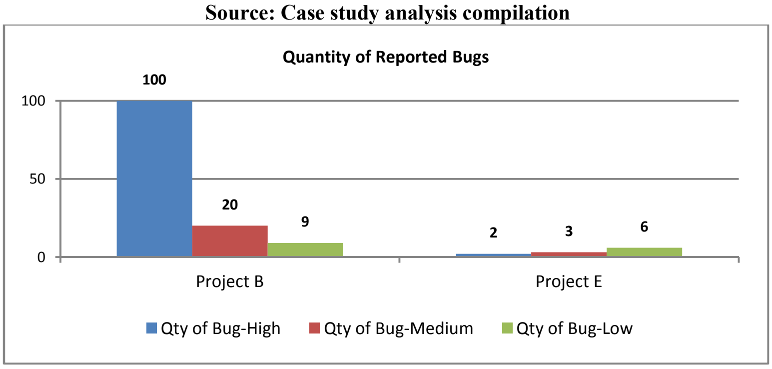


Figure 15 Quantity of Reported Bugs – SYNDES Technologies

In view from the collected data, Project B and Project E are the two projects which reported bugs were tracked and tabulated in Figure 15. Project-B was reported with 100 bugs with severity "high" for a project with 100 days duration but delayed with 30 days. Whereas project-E only reported with 2 "high" severity bugs of 80 days project duration with project delayed 20 days. Although both project delayed, Project-E delivered a better quality product with much lesser bugs compared to Project-B (i.e. reported with 2 high-severity bugs, 3 medium-severity bugs and 6 low-severity bugs). In short, there is less rework for Project-E.

5.3.3.3 System Requirement Specification Defect

System Requirement Specification (SRS) is a control document of baseline user requirement established during the Planning phase and is used by the project team for planning and execution. The project team will plan, schedule and develop the end product based on "this" set of user requirement. SRS should give the project team a "detail" understanding of the project scope outlining what are the expected deliverable items, modules, functions, products, services and supports. The sample data of the 8 projects were used as base-data in the measure phase determining the level of changes to user requirement during the PLC.

There are 7 projects (A, B, C, D, E, F & H) out of a total of 8 projects tracked in this work that was reported with changes made to baseline SRS. A total of 75% of the case company's projects required changes to user requirement (Figure 16) even after the SRS had been signed off. The level of changes to the SRS varied among projects; with 40% reported for Project A and B; 30% for Project-E; 20% for Project-F, 10% for Project-H and 5% for Project-D (Figure 17). This implies that there is a high chance that Project-A, B, C, D, E, F and H encountered rework during the PLC.

Source: Case study analysis compilation

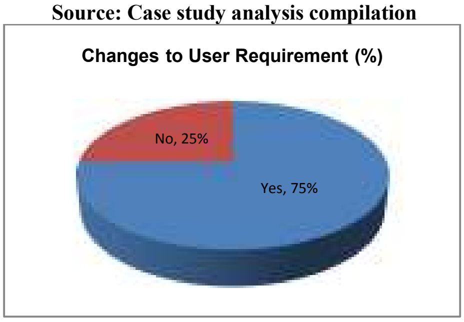


Figure 16 Changes to User Requirement – SYNDES Technologies

Source: Case study analysis compilation

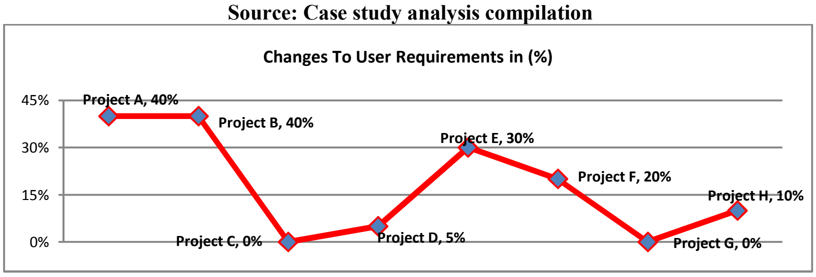


Figure 17 Percentage of Changes to User Requirement – SYNDES Technologies

5.3.3.4 Quality Assurance (QA) Testing Defect

Quality Assurance (QA) refers to the systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled. It is a systematic measurement, comparison with a standard, monitoring of processes and an associated feedback loop that confers error prevention. This systematic way of practices comparing baseline against actual outcome should be monitored and managed throughout the entire SDLC not limiting to a particular point of SDLC or project phase only.

Table 50 QA Testing in SDLC By Project – SYNDES Technologies

Phase	Planning			Analysis			Design			Implementation			Maintenance
Project	Pre	…	Post	Pre	…	Post	Pre	…	Post	Pre	…	Post	
Project A	×	×	×	×	×	×	×	×	×	×	×	√	
Project B	×	×	×	×	×	×	×	×	×	×	×	√	√
Project C	×	×	×	×	×	×	×	×	×	×	×	√	
Project D	×	×	×	×	×	×	×	×	×	×	×	√	
Project E	√	√	√	√	√	√	√	√	√	√	√	√	√
Project F	×	×	×	×	×	×	×	×	×	×	×	√	
Project G	×	×	×	×	×	×	×	×	×	×	×	√	
Project H	×	×	×	×	×	×	×	×	×	×	×	√	

Source: Case study analysis compilation

From the SDLC chart in Table 50, the team observed that there no consistencies of QA testing for SYNDES. In most cases (Project A, B, C, D, F, G & H; except Project-E), QA Testing only carried out when the end-product is developed or ready to deliver. The QA testing (i.e. by phases) on individual functional, modular, procedural etc. were conveniently omitted until the completion of the product (i.e. at the post-stage of Implementation stage). As such, QA testing is only carried out on executable file which is based on User Acceptance Test (UAT) Plan. The only project which performs QA Testing throughout SDLC is Project-E.

5.3.3.5 Project-related Document Defects

Project Schedule, SRS, System Specification, Functional Specification, Unit Test Plan, User Acceptance Test Plan are some examples of mandatory useful documents required in the IT project management cycle [124, 127, 148]. These documents provide guidelines, scope boundaries and directions to project team allowing team members to track actual performance against baseline. However, the research team observed from Table 51 that SYNDES only produced some of the project documents which covered **brief introduction** about the related project.

Table 51 Document Status By Project – SYNDES Technologies

Phase	Project Schedule			SRS			System Specification			Functional Specification			Unit Test Plan			Code Walk Through			Project Review		User Acceptance Test Plan		
Project	B	D	N	B	D	N	B	D	N	B	D	N	B	D	N	B	D	N	I	F	B	D	N
Project A		√		√			√			√					√	√			√			√	
Project B		√		√			√			√					√	√			√			√	
Project C		√		√			√			√					√				√			√	
Project D		√		√			√			√					√			√	√			√	
Project E		√		√			√			√					√			√	√			√	
Project F		√		√			√			√					√			√		√		√	
Project G		√		√			√			√					√							√	
Project H		√		√			√			√					√			√	√			√	
Note: **B** = Brief; **D** = Detail; **N** = None **I** = Informal; **F** = Formal																							

Source: Case study analysis compilation

5.3.3.5.1 Project Schedule Defects

In project management, a **schedule** consists of a list of a project's terminal elements with intended start and finish dates [30]. Terminal elements are the lowest elements in a schedule, which is not further subdivided. In other words, terminal elements are smaller manageable detail tasks/items. Those items are often estimated in terms of resource requirements, budget and duration, linked by dependencies and scheduled events. Before a project schedule can be created, the project manager and project leader should have a work breakdown structure (WBS), an effort estimate for each task, and a resource list with availability for each resource [31]. Though the techniques of scheduling are well developed, they are inconsistently applied throughout industry.

The case company has a code of practice to have its' project schedule constantly updated, showing the state-of-art of the project at any point of the PLC. However, the project schedule does not reflect the project health as items in the SRS are not mapped into the project schedule. The current way of managing projects result in redundant efforts in ensuring SRS items are performed and the schedule is always up-to-date [150]. As such, the tasks appearing in project schedules do not reflect fulfillment of items in the SRS and hence making project tracking and monitoring less effective and inefficient.

Furthermore, it is a common practice in the case company to schedule a single task with 5, 10, 15 or 20 man-days of effort. This manner of high-level descriptive of task scheduling creates unhealthy assumptions with the developer [30] which will further lead to rework and more changes to the SRS requirements.

5.3.3.5.2 System Requirement Specification Defects

A **system requirements specification (SRS)** is a structured collection of information that embodies the requirements of a system. A business analyst (BA), sometimes titled system analyst, is responsible for analyzing the business needs of their clients and stakeholders to help identify business problems and propose solutions. Within the SDLC domain, the BA typically performs a liaison function between the business side of an enterprise and the information technology department or external service providers.

The case company has been practicing "brief" SRS for all projects. These SRS items were observed omitting the details of each SRS items. For example, a "single" statement of high level SRS item can easily be translated into 10 man-days effort requiring two programmers working on it at the same time (i.e. become 20 man-days). Therefore, any high level descriptive of SRS items would cause assumptions among the developer [30] which is harmful to project health as well as further leading to rework and more changes to SRS requirements.

Items in SRS are the main source or input for project scheduling [124]. Hence, it is important to break down items in SRS into smaller and manageable items so that mapping of SRS items against project schedule can be carried out more effective and efficient [30]. Only when items in SRS are being itemized and mapped into respective smaller manageable "task" in project schedule, the research team can assured that all items in SRS are taken care of. The next focus would be tracking, controlling, developing and delivering "these" SRS items in project schedule.

5.3.3.5.3 System Specification Defects

The System Specification establishes and defines the mission performance and technical requirements of the system, allocates requirements to functional areas, documents design constraints, and defines interfaces [127]. It guides vendor selection and the system development effort. The PM should ensure that this "technical requirements" is able to trace, in both directions. These technical requirements expressed in all specifications for low-level system end products through their parent intermediate specifications ultimately back to the overall System Specification [124]. The system specification is the output of the "development" phase [124] and traditionally, system specifications took the form of natural-language documents.

A good specification gives a complete statement of what the system is to do, without making any commitment as to how the system is to do it. A system specification is normally produced in response to user requirements specification (or SRS) or other expression of requirements, and is then used as the basis for system design [127]. Since the case company is adopting brief SRS, the

System Specification is disappointing too. As such, the research team can conclude that there is a strong positive relationship of System Requirement Specification versus System Specification. It is the Technical Lead's responsibility in producing detailed and useful System Specification in which describes the performance and operational requirements. It is a key top-level document from which program-unique specifications are derived.

5.3.3.5.4 Functional Specification Defects

In general, the **functional specification** states what the proposed system is to do. A functional specification is a formal document used to describe in detail for software developers a product's intended capabilities, appearance, and interactions with users [30]. The functional specification is a kind of guideline and continuing reference point as the developers write the programming code.

Typically, the functional specification for an application program with a series of interactive windows and dialogs which show the visual appearance of the user interface and describe each of the possible user input actions and the program response actions. A functional specification may also contain formal descriptions of user tasks, dependencies on other products, and usability criteria.

SYNDES claims that they produce brief spec-writing because they want to save time. Failing to write a spec is the single biggest unnecessary risk a company take in a software project [219]. Without functional specification, programmers and software engineers who dive into code tend to think they know what to do and where to start. Coding without functional specification is terribly unproductive. Programmers tend to write bad code and produce shoddy software, and they threaten their projects by taking gigantic risks which are completely uncalled for [219]. Another reason for not having proper spec-writing phase is that there exists system specification as a back-up. System Specification and Functional Specification are two different documents and is non-substitutable among them; what's more it is just a brief system specification.

5.3.3.5.5 Unit Test Plan Defects

The ultimate objective of testing is to ensure that the system performs as designed and, by extension, to ensure that it meets the user's needs. More specifically, testing is the process of exercising the system and its components to locate, investigate, and correct errors and bugs [124]. The goals of testing include ensuring that all system components work properly, finding errors and identifying their causes, revising or modifying the software and other components to eliminate errors, tracking the status of errors, and adjusting system performance and operating procedures as appropriate.

Even though test plan is constrained by resources (the computing platform, hardware, software, and peripherals), personnel, and time (in the form of the project schedule); product quality can be achieved via effective and efficient unit test plan [6]. Many IT professionals think of testing as a stage that comes near the end of IT product development. This is not true. Testing should be done during almost every phase of the IT product development life cycle [30]. Therefore, it is necessary for the project team to provide adequate testing and conduct testing throughout the project life cycle.

The case company was observed with non-existence of "unit test plan" for all the 8 projects. This culture of "**non-existence of unit test plan**" is unhealthy where testing forces are accumulated towards the end of SDLC with the hope to shorten development time by saving up the phase testing time.

Effective testing does not just happen; it must be carefully planned. A complete test plan incorporates testing strategies, testing procedures, test data, and a testing schedule [220]. The objective of test plan is to find and report as many bugs as possible to improve the integrity of a program. Although exhaustive testing is not possible, it is necessary to exercise a broad range of tests to achieve our goal. Unit Testing is done at the source or code level for language-specific programming errors such as bad syntax, logic errors, or to test particular functions or code modules. The unit test cases shall be designed to test the validity of the programs correctness [30, 31]. The relative cost to repair defects is 30*x* at the post-product release as compare to 1*x* and 5*x* at the 'requirement and analysis" phase and "coding and unit test" phase respectively [30, 220]. Hence, it is a "well-known and high cost" big mistake to leave testing at the end of SDLC and PLC.

5.3.3.5.6 Code Walk Through Defects

Code Walkthrough or Software Walkthrough is a form of software peer review "in which a designer or programmer leads members of the development team and other interested parties through a software product, and the participants ask questions and make comments about possible errors, violation of development standards, and other problems" [221]. In general, a walkthrough has one or two broad objectives: to gain feedback about the technical quality or content of the document; and to familiarize the technical team with the content.

In the IT industry, the possible list of documents for software walkthrough are software design document or program source code, use cases, business process definitions, test case specifications, and a variety of other technical documentation may also be walked through [124, 127, 221, 222]. Code Walkthrough is an effective tool in the areas of quality assurance and ease of maintenance. It was observed that 4 out of 6 six (>60%) of SYNDES' projects did not enforce code walkthrough. As a result, the developer may not expose to alternate methods and processes when the technical lead and QA administrator suggest and discuss improvements to the code. The existence of “gap” between these two technical teams may jeopardize the output quality, code quality, application performance as well as developer performance.

5.3.3.5.7 Project Review Defects

It is necessary and simpler in software project management for project manager conducting on-going schedule project reviews instead ad-hoc reviews. The fundamental objective of project review is to find out: (1) Has the team allotted the best possible resources? ; (2) Is this the best approach or does anyone have a better solution? ; (3) Does the project team need to incorporate requirement change? ; (4) Does the project team need to revise the project plan and schedule?

Just like the post project review, on-going project reviews are highly recommended so that the same ‘lessons learned’ can be implemented within the same project to minimize project issues pertaining to software quality, delivery schedule, budget, deviation from the requirements, overall impact on business etc.

SYNDES is practicing “informal” project review and most of the time is an ad-hoc review. No preparation is done prior to the meeting and the meeting is merely checking of the project status. It is important to have each team member prepare for the meeting to ensure it is an effective sharing session with problem raise and solution is discussed. Periodic project reviews also give the team a clear picture of what is expected of them at different stages. Reviews will help team members to put in their best performance.

5.3.3.5.8 User Acceptance Test Plan Defects

User Acceptance Testing (UAT) is a process to obtain confirmation that a system meets mutually agreed-upon requirements. UAT is a type of testing performed by the Client to certify the system with respect to the requirements that was agreed upon. This testing happens at the final phase of testing before moving the software application to market or production environment [30, 150]. The main purpose of this testing is to validate the end to end business flow. It does NOT focus on the cosmetic errors, spelling mistakes or system testing. This testing is carried out in separate testing environments with production like data setup. It is a kind of black box testing where two or more end users will be involved [127].

SYNDES views UAT Plan as a critical task for the entire PLC. The UAT Plan is usually created by SYNDES; reviewed and approved by customers. The business customers are the primary owner of these tests. At any time, there should have no critical defects open, business process works satisfactory and most importantly, UAT is sign off by the stakeholders. This practice of preparing detail UAT Plan should cultivate as the work culture in SYNDES to ensure good product quality delivery.

5.3.4 Relationship Between Deficiency Variables from Data Collection

5.3.4.1 Changes to User Requirements versus On-time Delivery

A plot of "Level of Changes Made to SRS" versus "Project Delivery Performance" (Figure 18 and Figure 19) showed a consistent pattern and a linear relationship between these two variables. When these two variables were plotted into a single scatter diagram in Figure 20, it was observed a positive correlation between these two variables. The observation concluded that an increase in percentage of "Changes to user requirements" will result in an increase in time taken (i.e. delay) to deliver a project for this case study. This means that **"***Percentage of changes to user requirement***"** is an important factor contributing to project delivery performance.

Source: Case study analysis compilation

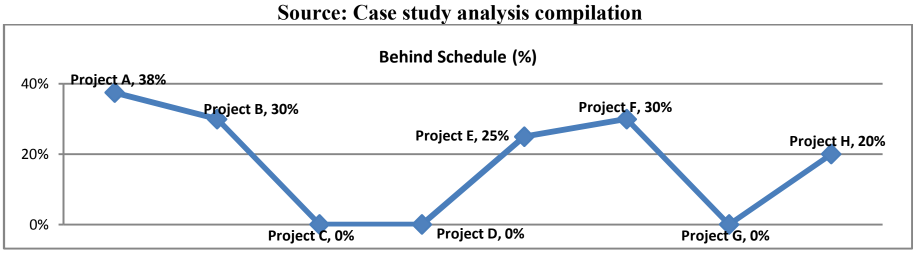


Figure 18 Project Delay (%) By Project – SYNDES [223]

Source: Case study analysis compilation

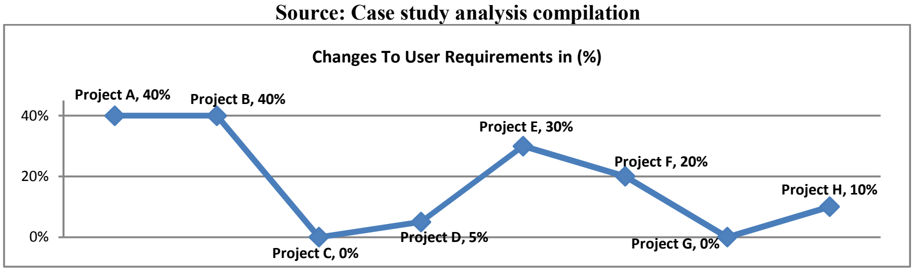


Figure 19 Changes To User Requirement (%) By Project – SYNDES [223]

Source: Case study analysis compilation

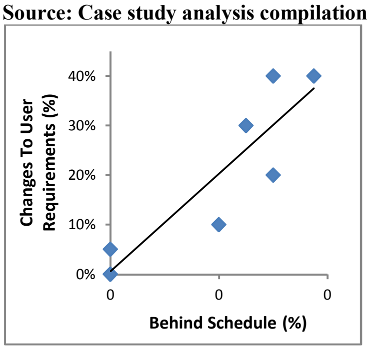


Figure 20 Scattered Chart - Changes to User Requirement (Y) Project Delay (X) – SYNDES [216]

5.3.4.2 Project Delay versus Planning Effort

5.3.4.2.1 Pie Charts and Line Graph

Source: Case study analysis compilation

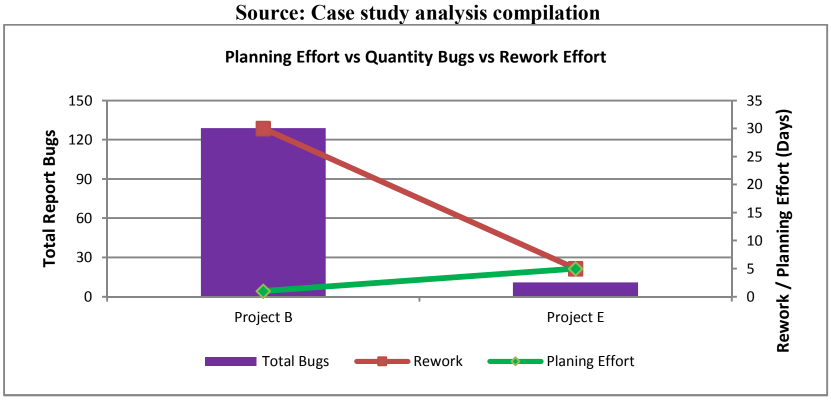


Figure 21 Planning Effort vs Quantity Bugs vs Rework Effort – SYNDES Technologies [216]

In support of the investigation, the authors aim to find out the root-causes contributing to SRS changes which have a positive relationship with project delivery performance. A preliminary analysis of the relationship between the variables of "Planning Effort", "Quantity of Bugs" and "Rework Effort" is outlined in Figure 21.

Figure 21 combined the variables of "Planning Effort", "Quantity of Reported Bugs" and "Rework Effort" for both Project-B (Phase-I) and Project-E. Project-E kick-started with five days of planning effort and resulted in eleven reported bugs which took the team five days to rectify the bugs. In contrast, Project-B (Phase-I) only took one day to plan and 129 bugs were reported. There exist a positive correlation in "Planning Effort" against "Reported Bugs" and "Rework Effort". Whenever there is an increase of "Planning Effort", there will be a reduction of "reported bugs" which leads to "less rework". Schwalbe [30] quoted that the relative cost to repair defects/bugs towards the end of the PLC is 30-times more than at the beginning of the PLC. This implies that proper project planning (by spending sufficient time at the start of PLC) in determining user requirements (i.e. SRS) is a crucial factor contributing to quality and product delivery.

5.3.4.2.2 Pareto Diagram

Both Table 52 and Table 53 outline the summary of variables for Project-B as a mean of variables comparison for project effectiveness and efficiency. This study has added another variable of "Cumulative of Reported Bugs" into our variable relationship investigation.

A Pareto Analysis was performed based on the above collected data. Pareto Analysis involves identifying the vital few contributors that account for most quality problems in a software system [30]. Pareto diagram are histogram, or column charts representing a frequency distribution that help identify and prioritize problem areas. Pareto analysis also called the 80-20 rule; meaning that 80% of problems are often due to 20% of the causes.

Table 52 Summary of Variables By Project

Variables	Planning Effort	SRS Status	Baseline Changes (%)	Unit Test Plan	System Specification Status	Functional Specification Status	Code Walkthrough Status	Reported Bugs
Project-B	1 day	Brief	High	None	Brief	Brief	Brief	129

Source: Case study analysis compilation

Table 53 Cumulative Reported Bugs for Project-B by SYNDES's Operation Framework

Project	System Infrastructure	Database	System Core	System Integrator	System Interface	Total
Project-B	5%	25%	25%	30%	15%	100%
Cumulative	**5%**	**30%**	**55%**	**85%**	**100%**	

Source: Case study analysis compilation

Since Project-B (Phase-I) is the least performing project, it was chosen to gauge this positive correlation between the variables of "Planning Effort" against "Total Reported Bugs" and "Rework Effort" using a Pareto Diagram.

It can be observed from the Pareto Diagram in Figure 22 that the high frequency of reported bugs for Project-B (Phase-I) is caused by insufficient code walkthrough referring to brief functional specification and brief system specification. The reason for not producing detailed project-related documents (i.e. Functional Specification, System Specification) is due to scope creep where changes are encountered (i.e. 40%) to the SRS. The root-cause of the recorded 40% of SRS changes is due to lack of project planning. In project management, effective planning is absolutely required if the individual or group wishes to deliver a finished project on time and on budget [30]. Project planning is one of the most important stages in Project Management because it defines the objectives of the project based on requirements gathered. Without Project Planning, the project will most likely fail [30, 31].

Source: Case study analysis compilation

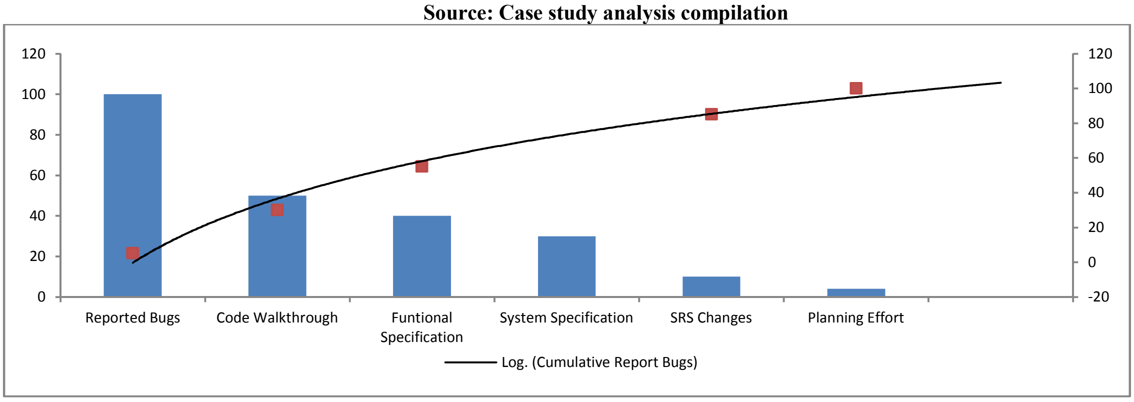


Figure 22 Pareto Diagram: Project-B – SYNDES Technologies [216]

Before even starting a project, a period of planning is necessary if one wants to successfully finish the work. But beginning on a project with no firm blueprint of action is likely only to jeopardize the whole process. Project planning is fundamental in order to avoid failure and disappointment. With proper project planning, the project team can focus and achieve the following: (1) Broadening the core team's understanding of the project scope ; (2) Determining delivery sequence and priorities ; (3) Providing access to product-specific know-how ; (4)

Managing the expectations of product developers in order to minimize last minute scope changes ; (5) Establishing the optimum process and schedule ; (6) Risk analysis, contingency planning and stress-testing of process ; (7) Ensuring ownership for tasks within the core team ; (8) Defining communication, escalation channels and managing the client's expectations ; (9) Ensuring Quality Assurance at all stages ; (10) Allocating and managing to budget.

5.3.4.3 Frequency of Quality Assurance versus Reported Bugs

Quality Assurance (QA) is any systematic process of checking to see whether a product or service being developed is meeting the specified requirements [30]. A quality assurance system is said to increase customer confidence and a company's credibility, to improve work processes and efficiency, and to enable a company to better compete with others. Today's quality assurance systems emphasize catching defects before they get into the final product.

Software quality assurance consists of a means of monitoring the software engineering processes and methods used to ensure quality. The methods by which this is accomplished are many and varied, and may include ensuring conformance to one or more standards, or delivering customer requirement list. QA is sometimes used informally as a synonym for software testing [224].

Table 54 Frequency of QA Testing in SDLC – SYNDES Technologies

Project	Phases of System Development Life Cycle (SDLC)						Reported Bugs	Rework
	Planning	Analysis	Design	Implementation	Pre-release Review	Maintenance		
Project-B	X	X	X	X	√	N/A	129	30 days
Project-E	√	√	√	√	√	N/A	11	5 days

Source: Case study analysis compilation

Table 54 shows the existence of QA Testing through SDLC for Project-B and Project-E. It was observed that Project-B performed QA Testing towards end of SDLC during the software pre-release stage. As such, a total of 129 "non-conformance" is detected; the project team requires 30 days of reworking on these "non-conformance" which will further lead to project delay and lower team morale and team motivation. Leaving the 'non-conformance" to the last stage of SDLC is the biggest risk as the impact may be significant which further delaying the project delivery [30, 31]. In contrast, Project-E practices a periodic QA Testing through the SDLC. The reported bugs are much lesser (only 11 reported bug) which require lesser rework effort.

Therefore, a periodic and consistent QA Testing is important in helping the company identify weaknesses and inconsistencies in the service or production method. Others advantages of QA activities are time efficiency, improving customer satisfaction and improving employee morale.

5.3.5 Six Sigma Calculation

Further effort was spent to identify the current Six Sigma performance level on software quality defects and delivery defects which is summarized in Table 55.

Table 55 Six Sigma Calculation – SYNDES Technologies

Quality Defect

Description	Defect	Project	* Unit	Opportunity for error per unit *	No. of defects	No. of Units	DPMO	Sigma Level
Reported Bugs	Quality Defect	Project B	Each bug – **High** severity	1 per bug	100	129	$\text{DPMO} = \left\{\frac{100}{129}\right\} \text{x } 10^6$ = 775,193	0.744
			Each bug – **Medium** severity	1 per bug	20	129	$\text{DPMO} = \left\{\frac{20}{129}\right\} \text{x } 10^6$ = 155,039	2.515
			Each bug –**Low** severity	1 per bug	9	129	$\text{DPMO} = \left\{\frac{9}{129}\right\} \text{x } 10^6$ = 69,767	2.978
		Project E	Each bug – **High** severity	1 per bug	2	11	$\text{DPMO} = \left\{\frac{2}{11}\right\} \text{x } 10^6$ = 181,818	2.408
			Each bug – **Medium** severity	1 per bug	3	11	$\text{DPMO} = \left\{\frac{3}{11}\right\} \text{x } 10^6$ = 272,727	2.105
			Each bug –**Low** severity	1 per bug	6	11	$\text{DPMO} = \left\{\frac{6}{11}\right\} \text{x } 10^6$ = 545,454	1.386

Note *:

High - An error that prevents the accomplishment of an operational function (e.g. system-hang, system-crash, etc.)
Medium - An error that adversely affects the accomplishment of an operational function; an error that is an operator/user inconvenience but does not affect operational functions of the Applications
Low - Minor errors like cosmetic errors, unimportant spelling mistakes (e.g. name of Customer) in report templates, etc

SRS Defects

Description	Defect	Unit	Opportunity for error per unit *	Project	Defect/Unit (DPU)	DPMO	Sigma Level
SRS Defect	Changes to SRS	Each SRS item	1 per SRS item	Project A	0.4 (or 40%)	$\text{DPMO} = \{0.4\}\text{x } 10^6$ =400,000	1.753
				Project B	0.4 (or 40%)	$\text{DPMO} = \{0.4\}\text{x } 10^6$ =400,000	1.753
				Project C	0		
				Project D	0.05 (or 5%)	$\text{DPMO} = \{0.05\}\text{x } 10^6$ =50,000	3.145
				Project E	0.3 (or 30%)	$\text{DPMO} = \{0.3\}\text{x } 10^6$ =300,000	2.024
				Project F	0.2 (or 20%)	$\text{DPMO} = \{0.2\}\text{x } 10^6$ =200,000	2.342
				Project G	0		
				Project H	0.1 (or 10%)	$\text{DPMO} = \{0.1\}\text{x } 10^6$ =100,000	2.782

Delivery Defection

Description	Defect	Unit	Opportunity for error per unit *	Project	Defect/Unit (DPU)	DPMO	Sigma Level

Quality Defect								
Description	**Defect**	**Project**	*** Unit**	**Opportunity for error per unit ***	**No. of defects**	**No. of Units**	**DPMO**	**Sigma Level**
Project Delay	Delivery Defect	Each delivery	1 per delivery	5 projects was delays	8 projects		$\text{DPMO} = \left\{\frac{5}{8}\right\} \text{x } 10^6$ = 625,000	1.181

Source: Case study analysis compilation

In overall, the Sigma level for SYNDES falls **between one sigma to three sigma performance**. Since it is common for many ordinary businesses to actually operate in between two to three sigma performance [74], any business performing below two sigma may require special attention as a means to improvement. Therefore, the case company required immediate attention to streamline its investigation into root-cause analysis which contributed to low sigma performance of 0.744σ in Project-B (Phase-I) for high-severity software quality defects. Project-B (Phase-I) is a project scheduled for 100 days but was delayed for 30 days. A total of 129 bugs were reported and 77.5% (i.e. 100 bugs) of those were at high severity, requiring immediate and ad-hoc attention where re-shuffling of technical staff(s) was necessary to give priority to fix the bugs within the shortest time-span possible (normally within two hours from the time the bug was reported) and prior to a return to their routine business operations.

On the other hand, the overall project delivery performance was disappointing where five out of eights projects were reportedly delayed with a computed sigma level of 1.181σ. In summary, there is only a 38% chance that a project will be delivered on time; other delayed projects were observed with a high percentage of SRS changes where minimal time was spent on project planning. Therefore, there is an urgent need to investigate "changes to SRS as an important factor contributing to project delay".

5.4 Analysis Phase

5.4.1 Introduction

IT Project management is the art of managing the project and its deliverables with a view to produce finished products or services [30]. There are many ways in which a project can be carried out and the way in which it is executed is project management. The list of project management activities are identifying requirements, establishing clear and achievable objectives, balancing the competing demands from the different stakeholders and ensuring that a commonality of purpose is achieved.

IT project management provides a competitive advantage for organizations seeking to improve their technology service capabilities. The goal is to manage the project's triple constraint--schedule, budget and scope--while delivering value to the business. In cases of where constraints are mismanaged, the overall project as a whole would be impacted. Therefore, the root-cause approach the research team undertakes for SYNDES is process investigation process improvement focusing on developing solutions to eliminate the root causes of business performance problems. In essence, the research team aims for a continuous process improvement effort which seeks to fix a problem while leaving the basic structure of the work process intact.

Despite data analysis in the measure phase, the authors furthered the investigation into project life cycle activities using a high-level process map, input-process-variables process map as well as looking into the main contributing variables to quality defects. The main objectives were to ensure all incidents are investigated and root causes are identified. The team started with a brainstorming session with the case company's technical and support teams. The possible causes of defections or hypotheses are: (1) Most of the IT projects are delayed due to existence of SRS changes; (2) Tendency of the project team to omit or prepare insufficient project documentation during the PLC; (3) Lack of planning effort during project start-up; and (4) Despite project delays, the project team faces significant rework from the large number of reported bugs.

5.4.2 Tools and Techniques

5.4.2.1 High Level Process Mapping

Upon project investigation, the general view of SYNDES' operational activities is summarized in Figure 23. The operational overview was presented in the phases of Project Life Cycle (PLC) where different resources are assigned at different phases of PLC. It also outlined each phase undertaken in the SDLC of SYNDES' project. Based on the current operational framework, the high level process map, input-process-variable and flow chart for SYNDES's IT projects are outlined in Figure 23, Figure 24, and Figure 25 respectively.

Source: Case study analysis compilation

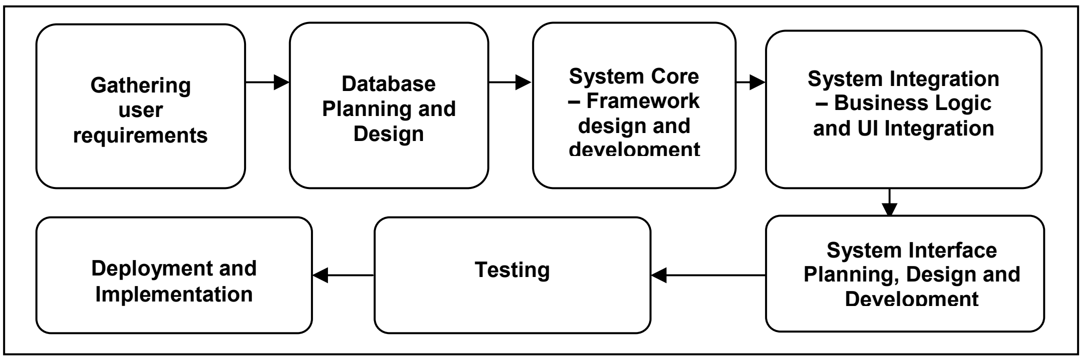


Figure 23 High Level Process Map – Current Project Operational Routine – SYNDES Technologies

Source: Case study analysis compilation

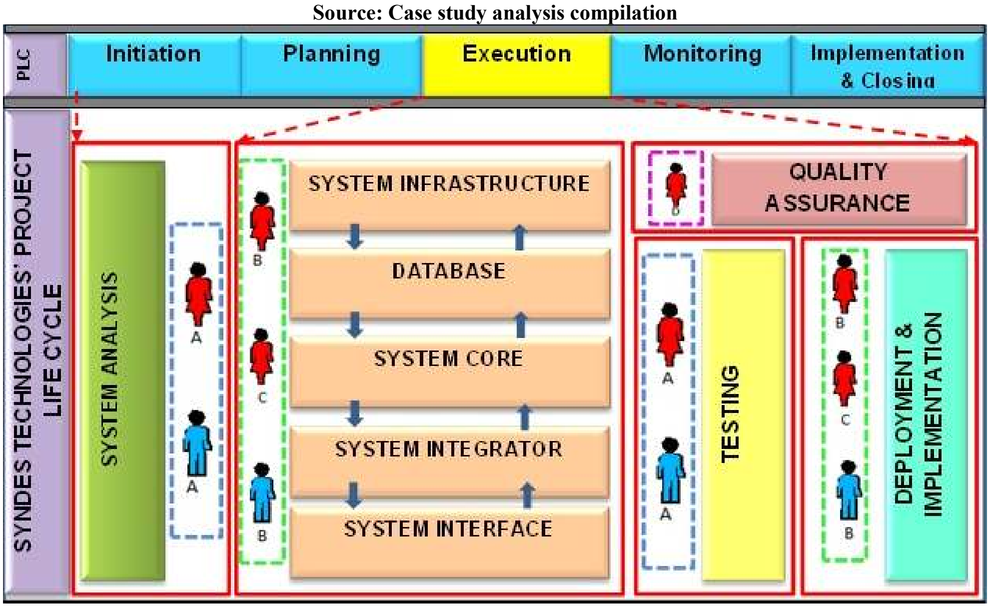


Figure 24 Operational Framework (Current) – SYNDES Technologies

5.4.2.2 Input-Process-Variables

Source: Case study analysis compilation

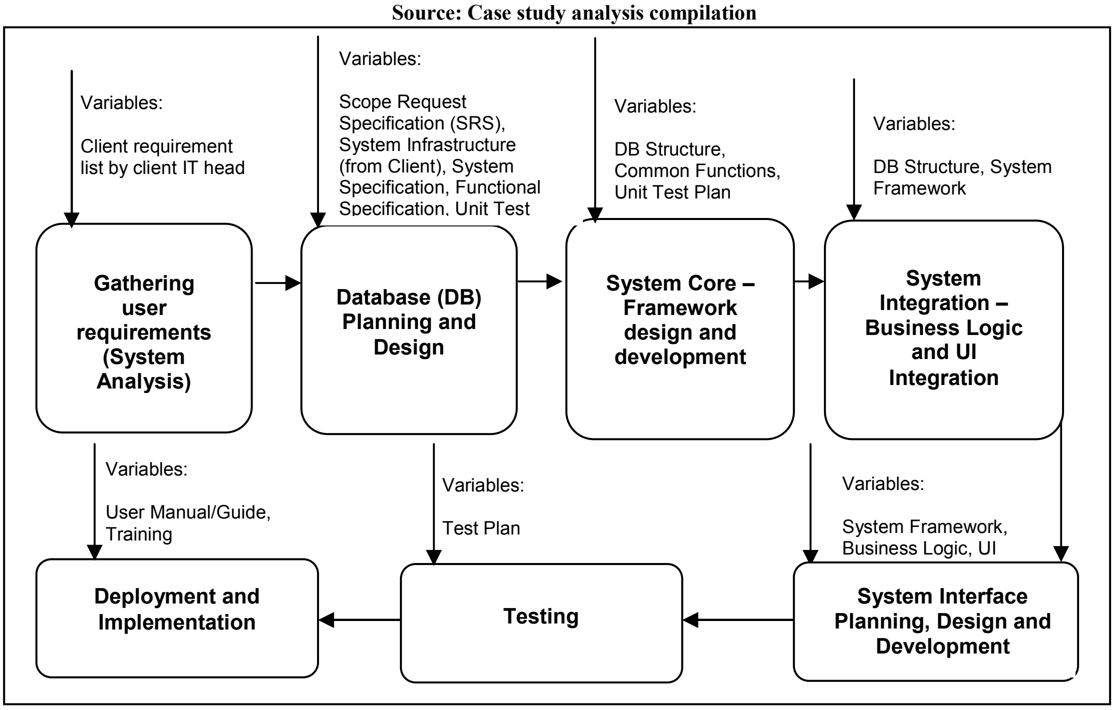


Figure 25 Input-Process-Variables Process Map – Current Project Operational Routine – SYNDES Technologies

Figure 23 and Figure 24 provide a general overview of information in-flow and out-flow within each system infrastructure components. Upon gathering of user requirements by the support staff, the list of user requirements is documented into SRS as a project-related document. Despite the SRS, documents related to system specification, functional specification, system infrastructure and unit test plan are used by technical staff to plan and design relevant system infrastructure which comprises of Database design, System Core, System Integration and System Interface. The list of respective information and documents required for system development are described in the input-process-variables (Figure 25) and the step-by-step flow chart about current project-related operational workflow is discussed in Figure 26. Once all the relevant software components are fully developed, the entire system will be put into testing phase and thereafter into implementation at the user side. The quality assurance executive is responsible for all testings pertaining to the developed system, i.e. Unit Testing, Integration Testing, Functional Testing, Logic Testing etc.

By benchmarking collected input variables from Figure 25, a listing of critical variables and controllable variables for respective sub-processes were tabulated. The identification of critical variables in Table 56 is consistent with findings resulting from the measure phase, i.e. customer requirement list (i.e. SRS), list of project documents (System Specification, Functional Specification, Unit Test Plan, User Acceptance Test Plan) and current operational framework are the potential areas which the research team can focus on as opportunities for continuous improvement.

Table 56 Critical and Controllable Variables- Current Project Operational Routine – SYNDES Technologies

Process	Critical Variables	Controllable Variables
Gathering User Requirements	Customer Requirement List	SRS, Functional Specification, Project Coordinator participation
Database Planning and Design	SRS, System Specification, Functional Specification, Unit Test Plan	QA and Project Coordinator participation, DB Unit Test Plan
System-Core	Common Functions, Unit Test Plan	Logic, Pseudo code, phase activities integration, QA participation
System Integration	System Framework	Website Design Reference, phase activities integration, QA and Project Coordinator participation
System Interface	Business Logic and User Interface (UI)	QA and Project Coordinator participation
Testing	Test Plan	QA and Project Coordinator participation

Source: Case study analysis compilation

5.4.2.4 Cause-and-Effect Diagram

A "semi-structured interview" was carried out to identify the root-cause of the potential problems which was identified in the earlier phase. The Cause and Effect diagram is a great tool for gathering group ideas and input by establishing categories of potential causes, rather than just focusing on a few typical areas. In Figure 27, five areas of business process are identified for investigation, i.e. Material, Measurement, Manpower, Procedure, Policies and Environment. The findings of *measurement* (i.e. (1) QA only takes place after system development completes; (2) Rework on software development and software testing and (3) System not meeting user requirement and business logic), *materials* (i.e. (1) Project related documents only captured high level details (brief); (2) Low level and detailed information only discovered during project development phase and (3) Lack of enforcement, control and management of project documents) and *environment* (i.e. (1) Delayed UAT and repeated UAT and (2) Different user groups were detected in the SDLC) from the Cause and Effect diagram are consistent with statistics and theory compiled from the Measure phase. The area of "Manpower" and "Environment" are the potential areas which have not been addressed in this investigation. The next step is to perform an in-depth analysis regarding how current operational work flow is affecting the overall resource allocation as well as work effectiveness and efficiencies.

5.4.2.5 Failure Modes and Effects Analysis (FMEA)

Upon completing of investigation using several tools mentioned in the Analysis phase, three brainstorming sessions were conducted with Ms. Jen and Ms. Miki. The potential causes for each failure are listed into the FMEA table. Ms. Jen and Ms. Miki were brief on the Risk Priority Number (RPN) table (Table 57). Once the RPN was assigned to each potential failure in the FMEA table, RPN was computed and listing of potential failures in descending priority order for improvement suggestions is tabulated shown in Table 58. The following are the top-five list of potential failure modes according to their risk priority number (RPN) from the FMEA filled-in by Ms Jen. In view of the result outcomes from the FMEA are mostly project-related activities and there exist strong relationship among these activities, the Six Sigma DMAIC process improvement initiative will be focusing on all the findings in the order of RPN: (1) Lack of operational QA and QC in SDLC; (2) Project schedule does not show the "true" or "actual" project status; (3) Adoption of inefficient and ineffective "Modified Waterfall" operational model; (4) Lack of planning in project start-up phase; (5) Most high impacted bugs are encountered during QA Testing; (6) Incomplete SRS and user requirement list; (7) Technical and Business knowledge gap among team members throughout SDLC; (8) Modules assigned are team member dependent and (9) Lacking or non-existence of weekly project progress review.

Table 57 Risk Priority Number (RPN) Guideline [181]

Severity			**Detection**	
1	No effect		1	Certain - fault will be caught on test
2	Very minor (only noticed by discriminating customers)		2	Almost Certain
3	Minor (affects very little of the system, noticed by average customer)		3	Low
4/5/6	Moderate (most customers are annoyed)		4/5/6	Moderate
7/8	High (causes a loss of primary function; customers are dissatisfied)		7/8	High
9/10	Very high and hazardous (product becomes inoperative; customers angered; the failure may result unsafe operation and possible injury)		9/10	Fault will be passed to customer undetected
Occurrence				
1	No known occurrences on similar products or processes			
2/3	Low (relatively few failures)			
4/5/6	Moderate (occasional failures)			
7/8	High (repeated failures)			
9/10	Very high (failure is almost inevitable)			

5.4.2.3 Flow Chart

Source: Case study analysis compilation

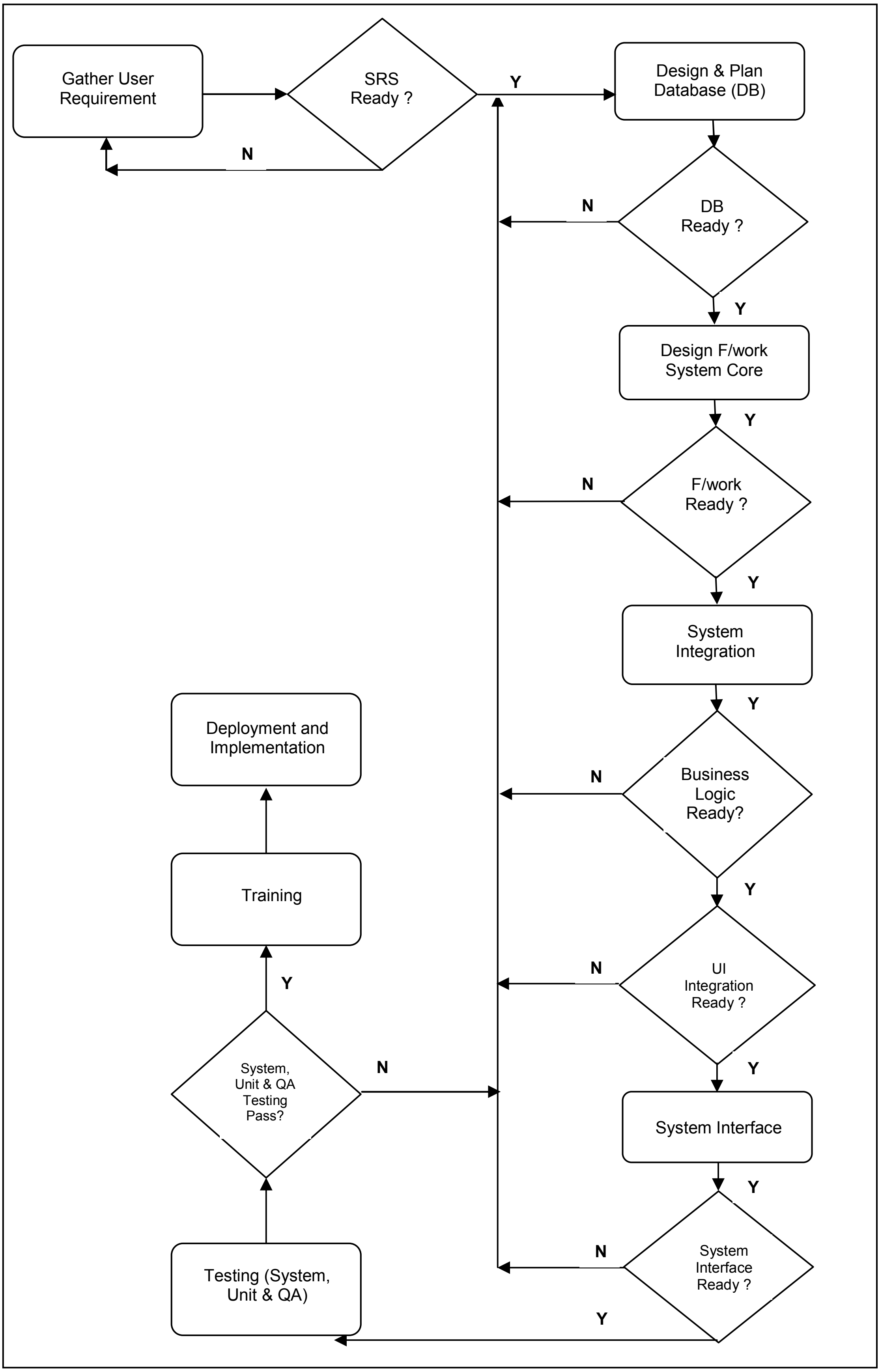


Figure 26 Flow Chart - Current Project Operational Routine – SYNDES Technologies

Source: Case study analysis compilation

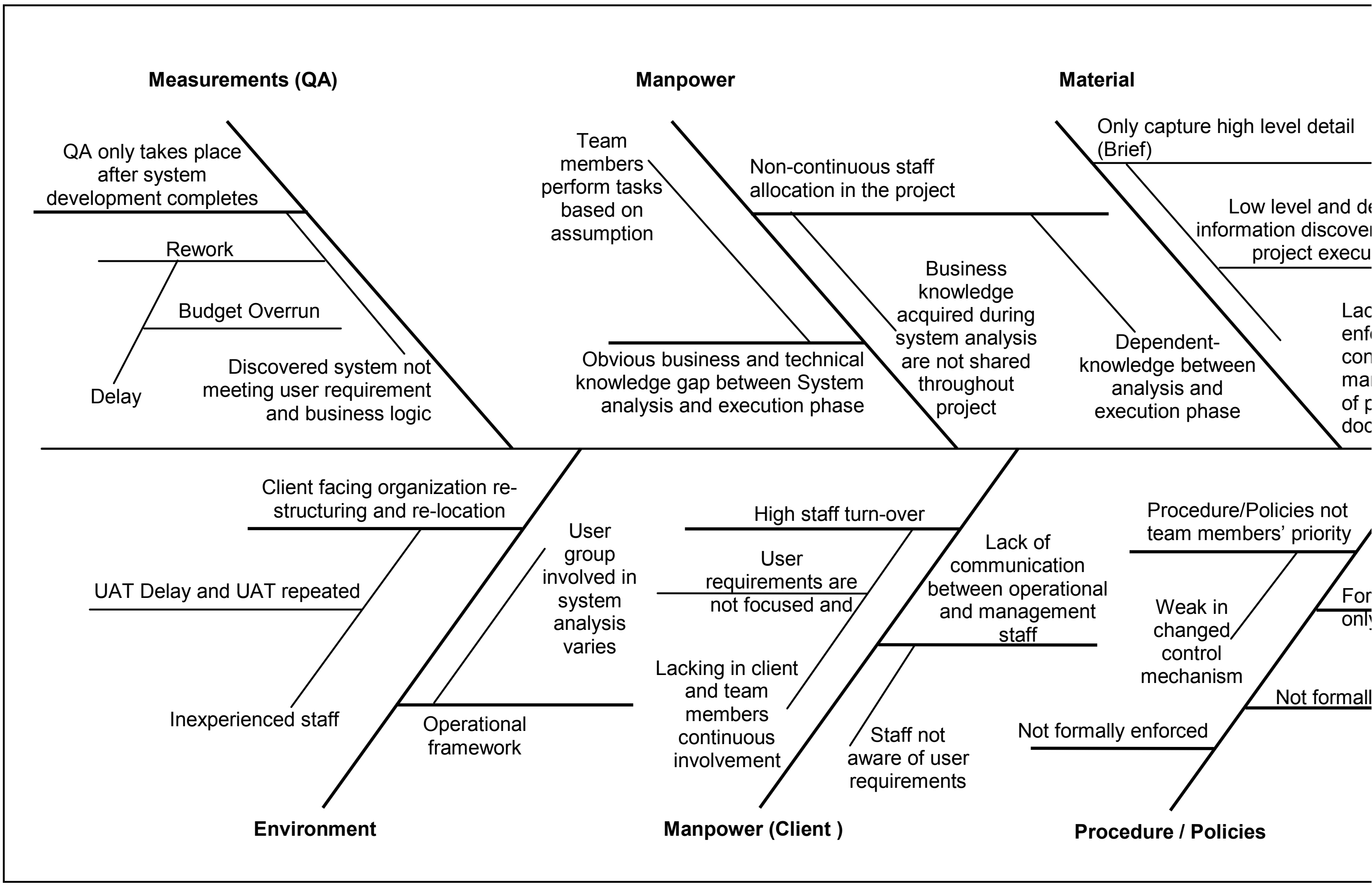


Figure 27 Cause and Effect Diagram – SYNDES Technologies

Table 58 Failure Mode and Effects analysis – SYNDES Technologies

Potential Failure Modes	Potential Causes	Current Controls	Risk Priority Number				Recommended Action
			Severity	Occurrence	Detection	RPN	
Lack of operational quality assurance and quality controlling in the cycle of SDLC process	• QA is not company formal directives • QA role is staff dependent	Informal. Team member has the option to conform and vice versa	7	6	6	252	• QA task should be allocated as part of project schedule • Management should make known to staff about company-level directives on quality assurance and quality control • A documented and step-by-step project activities flow is mandated
Project Schedule does not shows the "true" or "actual" project progress	• Project schedule are too general (like a template) which differ only in start and end dates for each project phase • Lack of proper handling, tracking and managing of tasks in SRS • Items in SRS was not reflected in project schedule • Distribution list of project schedule is not done formally	No Control	7	6	6	252	• Extend project schedule to map EVERY item from SRS which is ≥ 0.5 mandays • Mapping of SRS items into schedule give an overall view of how these items are fit into and affecting the project schedule. A more realistic schedule is expected • Suggest to make project schedule distribution a formal event via on-line • Aware the importance of updated project schedule. • Project schedule should be tracked and controlled.
"Modified Waterfall" Operational Model	• Much idle time was spent for source-code interdependencies from another phase and staff • Much miscommunications and mistake of assumptions • Milestones are more ambiguous	No Control	7	6	6	252	• Extend current operational model to a model which would reduce miscommunications and mistakes of assumptions • The model should focus on specific deliverables at each phase to reduce re-work effort
Lack of planning in the project start up phase	• Tendency to dive into "actual" output by the technical lead and support lead	No Control	6	6	6	216	• Sufficient planning effort is required to ensure user requirement are final and firm. • Technical issue and software issue should be raise up front • Both Technical Lead and support Lead should involve in the planning stage
High impact bugs encountered during QA Testing	• QA involvement only happened towards the end of the development stage • Team members in execution phased are lacking of business knowledge in testing the system (unit and UAT testing)	Only rely on respective developer's unit testing	6	6	6	216	• Should have formalized unit test plan • Suggest to include QA testing and Unit Testing as milestones in every phased • Suggest to include Project Leader, Technical Lead and Business Lead in QA testing • QA Test Plan should be planned accordance to: o items in SRS o client operational role (driver, admin staff, supervisor, finance executive, manager etc.) o business cycle flow

Potential Failure Modes	Potential Causes	Current Controls	Risk Priority Number				Recommended Action
			Severity	Occurrence	Detection	RPN	
Incomplete User Requirement List or System Requirement Specification (SRS)	**Client Side** • The process of SRS preparation is lead and dominant by client • Staff is lack of ownership **SYNDES Side** • Lack of in-depth and consistent involvement in SRS process • Lack of on-the-job observation	No Control	7	6	5	210	• Allocation of ONE technical and ONE business knowledge staff throughout the SDLC • Both technical lead and business lead should involve in the SRS process • Client is allowed to provide SRS but the team should take the lead in understanding and further analyze the requirements from the pre-prepare SRS
Business and technical knowledge gap among team members throughout cycle of SDLC	• Team member involved in SRS is not part of the team after SRS preparation • Each phase is handled by different team member/group • Inefficient and ineffective allocation of team members in the cycle of SDLC	No Control	6	5	6	180	• An observation of current operational flow and business cycle flow is necessary to equip team members with business knowledge • Suggest to involve both technical lead and support lead in the Brainstorming client-SYNDES session • Awareness the importance to embark 'continuous' client's business and operational knowledge throughout the project in order to reflect in SRS
Modules assigned are team member dependent	• Module and System Core are team-member-dependent • Work done by a team member is NOT transparent to others • A team member is unable to "pick-up" or 'follow-up" another team member's task • Lack of code walk-through or brainstorming	No Control	5	5	4	100	• Suggest to have code walk-through on random and selective basis • Prior code walk-through, one should prepare the "draft" functional specification (e.g. pseudo code) • This method of incremental "functional specification" is handy and useful in increasing staff transparency
Lack-of or Non-existence of weekly project progress review	• Weekly review discussion focused on general and high level item. Lack of in-depth discussion	No Control	2	2	2	8	• Suggest enforcing on weekly progress review for 1st project month. Thereafter depends on the PM discretion • Suggestion for a random brainstorming session for selected items/tasks in weekly-report

Source: Case study analysis compilation

5.4.3 Literature Review of Software Development Model

5.4.3.1 Introduction to Software Development Model

Quality has always been a main discussion topic for SYNDES as software quality has been exceptionally difficult to define. The bottom line, software quality in general is particularly elusive and hard to pin down because the word "quality" has many nuances and overtones. Quality often depends on the context in which a software component or feature operates. The quality of a software component is not an intrinsic property—the exact same component can be of excellent quality or highly dangerous depending on the environment in which it operates or the intent of the user.

Software Quality is often loosely equated with the activities of testing or quality assurance. However, testing can only tackle known unknowns. If the IT project team do not know what they are testing for; they are not conducting tests. But software, by its very nature is subject to unknown unknowns. No amount of functional or nonfunctional testing can be designed to detect and correct these problems. If the research team is taking advantage of cutting down team effort in software testing, the process linkage of helping to identify the correctness, completeness, security, and quality of developed computer software is broken. Therefore, testing is a necessary process of technical investigation, performed on behalf of stakeholders, that is intended to reveal quality-related information about the product with respect to the context in which it is intended to operate.

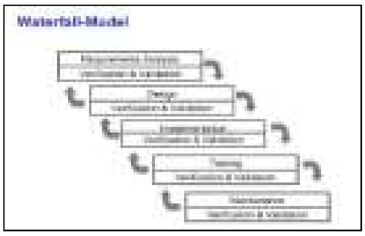
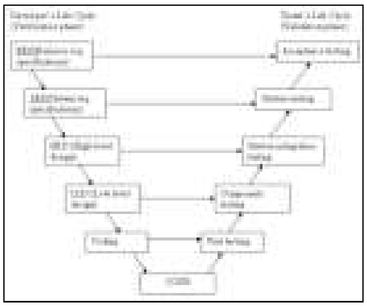
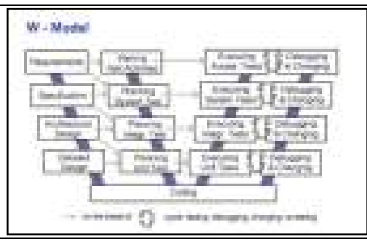
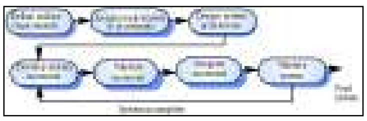
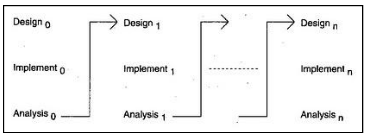
It is impossible to devise software tests for 'speculated conditions' in advance, but at least quality definition should be predictable before projects start. The existing operational process of SYNDES clearly shows the lack of "testing" (e.g. compatibility testing, functional testing, conformance testing etc.) from the PLC. What makes the matter worst is, Quality Assurance Testing and random testing (testing without unit test plan) are only executed when the software development completed, i.e. towards the end of SDLC. This is the time where project delivery time is crucial and project buffer is the least. In most cases, many project managers are willing to risk and sacrifice product quality by shortening the testing time-frame just to push the end product to the market place and then move on to next project [38].

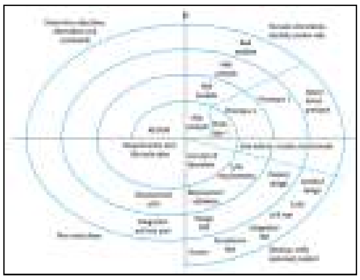
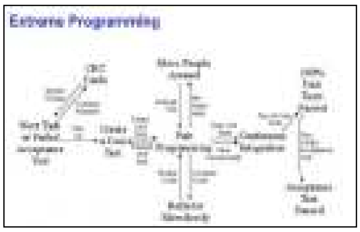
It was observed that SYNDES's Fleet Management System project was recorded with 100 cases of high-impacted bugs from total of 129 bugs (Figure 29). It is well-aware that fault-free software product most likely will not be affordable [38, 225], this study improves the case company's software development process by proposing a **modified-improved software development model with testing milestones cross different phases to minimize the occurrence of bugs especially the high-impacted bugs**.

5.4.3.2 Different Types of Software Development Model (SDM)

There are different software development models for software development life cycles. The general Software Process Models are ranging from static process model (i.e. Waterfall model [226, 227], V-model [226, 227], W-Model), incremental process model [226] and modern approaches (i.e. iterative process model [226], eXtreme programming etc.). A comprehensive literature review of various SDMs is discussed in Year-2 report and the details of each SDM are summarized in Table 59.

Table 59 analysis of software Development Model

No	Description	Picture Representation
Waterfall Model [228]	One of the pioneer models for software development. It is the most common and classic of life cycle models, also referred to as a linear-sequential life cycle model [229]. Each activity in the software development must be completed before the next activity can begin. A return in the development process was only possible to an immediate previous phase [228]. Unlike other models, phases do not overlap in a waterfall model. Testing directly follows the implementation, i.e. activities for testing could first be started after the implementation. This model is only appropriate when the requirements are well-understood or can be frozen [126]. The classic waterfall model and its variations assume a software development project where work steps can be clearly detailed before they are executed. In an attempt to overcome the shortcomings of the waterfall model many new software development approaches such as iterative enhancement [230], rapid prototyping [231] evolutionary prototyping and incremental development [232] have been suggested.	
V-Shaped Model [233]	It is a sequential path of execution of processes. Each phase must be completed before the next phase begins. Testing is more emphasized in this model on the verification stage and testing [226], which overlap all the other stages of the software development lifecycle. The testing procedures are developed and planed early in the life cycle before any coding is done, during each of the phases preceding implementation. Before development is started, a system test plan is created. The test plan focuses on meeting the functionality specified in the requirements gathering. The "V" is also a synonym for verification and validation [228]. In short, the V-shape model is formed due to the upward direction of testing, i.e. test execution [3]. In addition to being a highly disciplined approach, it promotes meticulous design, development, and documentation necessary to build stable software products. Lately, it is being adopted by the medical device industry [234].	
W-Model [228]	It is presented based on the general V-model and the testing disadvantages previously mentioned on Waterfall model and V-Shaped model are removed. In the V-Shaped model, the test process usually receives too little attention in the models presented and usually appears as an unattractive task to be carried out after coding. In order to place testing on an equal footing, a second "V" dedicated to testing is integrated into the model. Both "V"s together give the "W" of the W-model; which "Strengthen the Bond Between Development and Test"	
Incremental Model [235]	It is an intuitive approach to the waterfall model. Multiple development cycles take place here, making the life cycle a "multi-waterfall" cycle. Cycles are divided up into smaller, more easily managed iterations. Each iteration passes through the requirements, design, implementation and testing phases [229]. A working version of software is produced during the first iteration, so you have working software early on during the software life cycle. Subsequent iterations build on the initial software produced during the first iteration.	
Iterative Model [226, 233]	With Iterative development, the project is divided into small parts. This Iterative model allows a software company to spot and mend problems at the earlier stages of the software development lifecycle, which makes the development process more flexible [5]. This allows the development team to demonstrate results earlier on in the process and obtain valuable feedback from system users [226]. The aim is achieved by breaking down the whole lifecycle into several iterations, thus handling the process in smaller portions. The iterative model allows creating the initial version of a software product straight after the first iteration [5]. Often, each iteration is actually a mini-Waterfall process with the feedback from one phase providing vital information for the design of the next phase. In a variation of this model, the software products, which are produced at the end of each step (or series of steps), can go into production immediately as incremental releases [226]	

No	Description	Picture Representation
Spiral Model [226, 236]	It is similar to the incremental model, with more emphases placed on risk analysis [226]. The spiral model has four phases: Planning, Risk Analysis, Engineering and Evaluation. A software project repeatedly passes through these phases in iterations (called Spirals in this model). The baseline spiral; starting in the planning phase, requirements are gathered and risk is assessed. Each subsequent spiral builds on the baseline spiral. Requirements are gathered during the planning phase. In the risk analysis phase, a process is undertaken to identify risk and alternate solutions. A prototype is produced at the end of the risk analysis phase. Software is produced in the engineering phase, along with testing at the end of the phase. The evaluation phase allows the customer to evaluate the output of the project to date before the project continues to the next spiral.	
Extreme Programming [228]	The eXtreme Programming is an approach to development, based on the development and delivery of very small increments of functionality [226]. It relies on constant code improvement, user involvement in the development team and pair wise programming. Taking a simplistic view of the model one could say that extreme programming does not use specifications. The test cases initially defined are used as a description of the requirements [228]. These test cases are then used after the implementation to help check the sub-product. This then leaves just the testing activities as tasks up to the point of implementation. The requirements for the system to be developed are then extracted from the specified test cases.	

Source: Case study analysis compilation

5.4.3.3 Comparison of Different Types of Software Development Model (SDM)

Despite the evolution of software development models from traditional approach to modern approaches, the sole objective of SME's management team is to develop a model that on the one hand comes close to reality i.e. that is suitable in practice and on the other hand serves to give structure to the process of software development [237]. Most of the models have their level of some deficiencies with regard to PLC's activities; hence it is wise to spend some effort in analyzing the strengths and weaknesses for each software development models (Table 60) prior deciding on one.

The key differences between these methodologies are to do with the way how the development activities among the PLC balance features against limited resources. More specifically, different methodologies suit different types of teams, software and business environments. Therefore, it is vital to customize the SDM in particular if the existing methodologies result in too much rework, schedule slippage, scope creep, increased number of reported high-impact bugs, etc.

Table 60 Comparisons of Different Software Development Model

	Software Development Model	Advantages	Disadvantages
1.	**Waterfall Model** **Pre-condition:** Appropriate when the requirements are well-understood or can be frozen [126, 226, 229] **Application**: Widely used in military and aerospace industries [126]	• Widely used and known (in theory!) [226] • Simple and easy to use and understand [226, 228, 229] • Applicable for small and relatively easy software [229] • Easy to manage due to the rigidity of the model – each phase has specific deliverables and a review process [229] • Reinforces good habits: define-before- design, design-before-code [226] • Phases are processed and completed one at a time [229] • Works well on mature products and weak teams [226]	• Expensive [126, 226], time consuming [126], high amounts of risk [229] and uncertainty [229], just like "swimming upstream" [226] • Inflexible and unsuitable for complex long-term software projects [229] • No working software is produced until late during the life cycle [229] • Poor model for long, ongoing, complex and object-oriented projects where requirements are at a moderate to high risk of changing [229] • Preparatory tasks for the testing were not clear [228] • Testing as the last activity before release, could be relatively easily shortened or omitted [228] • The expense of the removal of faults and defects found is only recognizable through a return to the implementation phase [228] • Has the difficulty of accommodating change after development is underway [126] • Software is delivered late in project, delays discovery of serious errors [226] • The Waterfall model takes a static view of requirements which makes it difficult to respond to changing customer requirements [126] and adjusting scope during the life cycle can kill a project [229] • Significant administrative overhead, costly for small teams and projects [226, 238] • Doesn't reflect iterative nature of exploratory development and unrealistic to expect accurate requirements so early in project [226] • Idealized, doesn't match reality well [226]

2.	**V-Shaped Model**
	
	• The V-shaped model should be used for small to medium sized projects where requirements are clearly defined and fixed.
	• The V-Shaped model should be chosen when ample technical resources are available with needed technical expertise
		• Simple and easy to use [239].
		• Each phase has specific deliverables [239].
		• Higher chance of success over the waterfall model due to the development of test plans early on during the life cycle [239]
		• Works well for small projects where requirements are easily understood [239]
			• Very rigid, like the waterfall model [239]
			• Little flexibility and adjusting scope is difficult and expensive [239]
			• Software is developed during the implementation phase, so no early prototypes of the software are produced [239]
			• Model doesn't provide a clear path for problems found during testing phases [239]
			• the coarse division into constructive work (including the implementation) on the left-hand side of the "V" and the more destructive tasks on the right-hand side [228]
			• From the view of testing, both the Waterfall model and V-Shaped model are deficient in various ways [4] as discussed in the following:
			  • the test activities first start after the implementation
			  • the connection between the various test stages and the basis for the test is not clear
			  • the tight link between test, debug and change tasks during the test phase is not clear

3.	**W-Model**	• Testers and the developers are entrusted with tasks and are seen as an equal-rights partnership [228] • The early collaboration and the tight co-operation between the two groups can often in practice avoid conflict meetings [228] • The model emphasises the fact that testing is more than just construction, execution and evaluation of test cases [228]	• Models simplify the real facts. In practice there are more relations between the different parts of a development process [228] • The model does not clarify the expenditure needed for resources that need to be assigned to the individual activities [228] • It appears that different activities have an equal requirement for resources (time, personnel, etc.). In practice this is certainly not the case [228] • In each project the most important aspects may vary and so therefore the resource allocation is unlikely to be equal across activities. For highly critical applications the test activities certainly have higher weighting or at least equal weighting with other activities [228]
4.	**Incremental Model**	• Generates working software quickly and early during the software life cycle [239] • More flexible – less costly to change scope and requirements [239]	• Each phase of an iteration is rigid and do not overlap each other [239] • Problems may arise pertaining to system architecture because not all requirements are gathered up front for the entire software life cycle [239]

	Software Development Model	Advantages	Disadvantages
	Pre-condition: • When requirements of the complete system are clearly defined and understood • When there is a need to get a product to the market early • When resources with needed skill set are not available	• Easier to test and debug during a smaller iteration [239] • Easier to manage risk because risky pieces [239] are identified and handled during its iteration [239] • Each iteration is an easily managed milestone [239] • Generates working software quickly and early during the software life cycle [233] • More flexible – less costly to change scope and requirements [233] • Easier to test and debug during a smaller iteration [233] • Customer can respond to each built [233] • Lowers initial delivery cost [233] • Easier to manage risk because risky pieces are identified and handled during it'd iteration [233]	
5.	**Iterative Model** **Pre-condition:** • When requirements of the complete system are clearly defined and understood. • When the project is big	• In iterative model, task activities are building and improving the product step by step. Hence task activities can track the defects at early stages. This avoids the downward flow of the defects [233]. • In iterative model can obtain reliable user feedback. When presenting sketches and blueprints of the product to users for their feedback, project team will be prompted effectively to imagine how the product will work [233]. • In iterative model less time is spent on documenting and more time is given for designing [233]	• Each phase of an iteration is rigid with no overlaps [233] • Costly system architecture or design issues may arise because not all requirements are gathered up front for the entire lifecycle [233]
6.	**Spiral Model** **Pre-condition:** • When costs and risk evaluation is important • Appropriate for medium to high-risk projects • When users are unsure of their needs • When requirements are complex • For new product line • Significant changes are expected (research and exploration)	• High amount of risk analysis [226, 239] • Good for large and mission-critical projects [226, 239] • Software is produced early in the software life cycle [226, 239]	• Can be a costly model to use [226, 239] • Risk analysis requires highly specific expertise [226, 239] • Project's success is highly dependent on the risk analysis phase [226, 239] • Doesn't work well for smaller projects [226, 239] • The model work best for large projects only, where the costs involved are much higher and system pre requisites involves higher level of complexity [240] • It needs extensive skill in evaluating uncertainties or risks associated with the project and their abatement [240] • It works on a protocol, which needs to be followed strictly for its smooth operation [240] • Sometimes it becomes difficult to follow this protocol. • Evaluating the risks involved in the project can shoot up the cost and it may be higher than the cost for building the system [240] • There is a requirement for further explanation of the steps involved in the project such as breakthrough, blueprint, checkpoints and standard procedure [240]
7.	**ExTreme Programming**	• Lightweight methods suit small-medium size projects [226] • Produces good team cohesion [226] • Emphasizes final product [226] • Iterative [226] • Test based approach to requirements and quality assurance [226]	• Difficult to scale up to large projects where documentation is essential [226] • Needs experience and skill if not to degenerate into code-and-fix [226] • Programming pairs is costly [226]

Source: Case study analysis compilation

5.4.4 SYNDES Technologies: Software Development Model

5.4.4.1 Introduction

In view of the SYNDES's Software Development Model in Figure 24, the case company is adopting the Modified Waterfall model, which is a step ahead of the traditional Waterfall approach. However, this "modified model" uses the same phases as the pure waterfall approach where it does not adopt the resource allocation in a continuous basis throughout the PLC.

This Modified Waterfall Model is more flexible than the pure waterfall model. If there is personnel continuity between the phases, documentation can be substantially reduced. Furthermore, implementation of areas which is easy only requires less effort and less resource. However on the other side, milestones are more ambiguous than the pure waterfall due to **mis-communication** and **mistaken assumptions** between team members whenever project activities are performed in parallel. There is a **lack of controlling and managing effort** in performing formal project review and code walk-through during the project execution phase. As a result, these **unforeseen inter-dependencies between tasks/activities** in the project schedule can create problems; in turn lead to rework, project delay, cost overrun and changes to requirement.

In the real-world of IT development, however, one can discover issues during the database design or system core stages that point out errors or gaps in the user requirements. Although this modified waterfall method allows SYNDES to return to an earlier phase; this involves costly rework and affects team motivation. Furthermore, each completed phase requires formal review and extensive documentation development which SYNDES has overlooked. Thus, oversights on testing effort during the execution phase have resulted in more head-count requested in the next maintenance phase. In essence, testing effort only comes into picture when coding is near to completion. Much effort is focused on Quality Assurance (QA) testing which generally based upon User Acceptance Test (UAT) plan. There isn't any formal unit test plan in place and unit testing are informally carried out by respective programmer without proper reviewing process. The ultimate baseline is to minimize the unnecessary rework caused by lack of unit testing at each project phase. Oversights in testing particularly are expensive to correct later.

The problems with the case company's SDM created an awareness of needing to adopt a new software development model which would allow better planning in resource utilization in return for minimizing the occurrence of SRS changes. In summary, there are many existing models for system developments of different project sizes and requirements. Each model has its' advantages and disadvantages, and each model tries to eliminate the disadvantages of the previous model and further improve or enhance on its advantages to cope with fast evolving IT needs.

Following are the important criteria for consideration prior proposing a SDM for SYNDES adoption:

- SYNDES has limited resources to move between projects and also between phases in the project life cycle
- Most of the SYNDES' projects are of medium term, i.e. 3-6 months duration. Highly complex and rigid SDM is not recommended.
- The proposed SDM should have the capability of solving SYNDES core issue, i.e. SYNDES was reported with high percentage of "high impacted bugs".

In view of the above mentioned criteria, the author propose a **modified-improved software development model with testing milestones cross different phases to minimize the occurrence of bugs especially the high-impacted bugs**. At the same time, resources involved in the proposed SDM are flexible as it greatly depends on individual project scope. The proposed W-Model integrated a second "V" testing into the model which strengthens the bond between software development and testing as well as makes the development process more flexible.

5.4.4.2 V-Shaped Model to W-Model

The V-model promotes the idea that the dynamic test stages (Figure 28) use the documentation identified on the left hand side as baselines for testing. Early test preparation finds faults in baselines and is an effective way of detecting faults early. This approach is fine in principle and the early test preparation approach is always effective. However, there are two problems with the V-Model as normally presented.

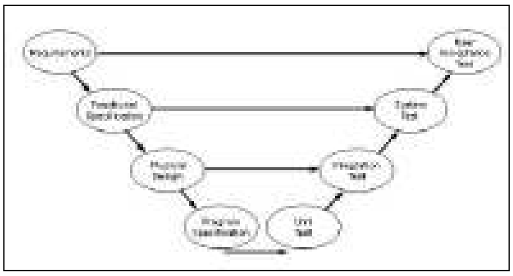


Figure 28 The V-Model of Testing [241]

The V-Model with early test preparation (Figure 29) is rarely a perfect, one-to-one relationship between the documents on the left hand side and the test activities on the right [241]. For example, functional specifications don't usually provide enough information for a system test. System tests must often take account of some aspects of the business requirements as well as physical design issues for example. System testing usually draws on several sources of requirements information to be thoroughly planned. V-Model has little to say about static testing. The V-Model treats testing as a back-door activity on the right hand side of the model [241]. There is no mention of the potentially greater value and effectiveness of static tests such as reviews, inspections, static code analysis and so on. This is a major omission and the V-Model does not support the broader view of testing as a constantly prominent activity throughout the development lifecycle.

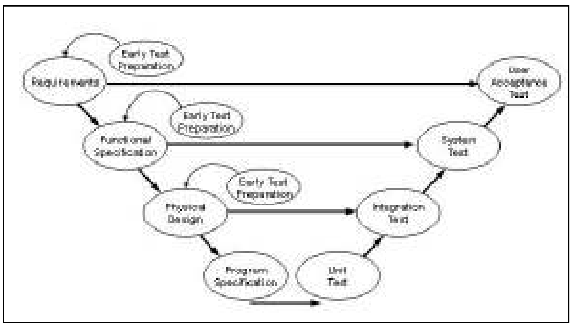


Figure 29 The V-Model with early test preparation [241]

Paul Herzlich introduced the W-Model approach in 1993 [241]. The W-Model attempts to address shortcomings in the V-Model. Rather than focus on specific dynamic test stages, as the V-Model does, the W-Model focuses on the development products themselves. Essentially, every development activity that produces a work product is shadowed by a test activity. The purpose of the test activity specifically is to determine whether the objectives of a development activity have been met and the deliverable meets its requirements. In its most generic form, the W-Model presents a standard development lifecycle with every development stage mirrored by a test activity [241]. On the left hand side, typically the deliverables of a development activity (for example, write requirements) is accompanied by a test activity test the requirements and so on. If an organization has a different set of development stages, then the W-Model is easily adjusted to its situation. The important thing is: the W-Model of testing (Figure 30) focuses specifically on the product risks of concern at the point where testing can be most effective [241].

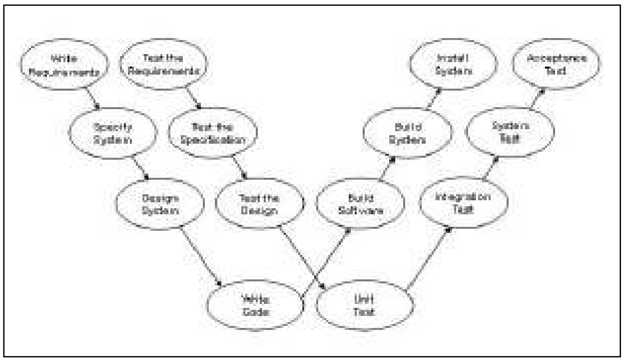


Figure 30 The W-Model of testing [241]

It is clear in the early development phases where testing activities must be carried out. It is not only the planning and management tasks that have to be carried out but also, for example, as the system is divided into components the corresponding test cases for checking the components interfaces can also be developed [241]. This is where the **operational model of SYNDES can be modified and adjusted to V-Shaped and then to W-Model**. When the tasks that a particular component should undertake are clear then the test cases to check these tasks lie relatively open.

Should these considerations be first placed at the integration test phase (as the V-model suggests) then a considerable increase in cost is necessary - the detailed knowledge of the tasks of the component must first be relearned.

No model clarifies the cycles between testing with defect discovery, debugging with defect localization and the implementation of changes to remove defects together with re-testing [237]. The necessarily tight interaction between testing and the changes in implementation are clarified on the right-hand side of the W-model. This side contains not only the “destructive” test activities as in the V-model but also the “constructive” change activities that are carried out as a result of the discovery of faults and defects.

5.4.4.3 SDM Summary

There may be practical reasons for incorporating static and dynamic test techniques and the decision is based on an evaluation of product risks and how best to address them. The W-Model does not enforce a project symmetry that does not (or cannot) exist in reality [237]. The W-model does not impose any rule that later dynamic tests must be based on documents created in specific stages (although earlier documentation products are nearly always used as baselines for dynamic testing) [237]. In the case of SYNDES projects adopting any of the above mentioned methods, requirements and designs are needed to be documented in multiple models so system testing might be based on several of these models (spread over several documents).

This study proposed the adoption of W-Model into testing of business strategy. Having identified the specific risks of concern, products that need to be tested are specified; then select test techniques (static reviews or dynamic test stages) to be used on those products to address the risks; then schedule test activities as close as practicable to the development activity that generated the products to be tested.

5.4.5 Summary

This study posted and grouped the investigation into two broad categories of output measures and input/process measures. The summarized root causes hypothesis for SYNDES are:

- Inefficient and ineffective of resource allocation in existing SYNDES’s operational framework result in mis-communication among team members
- Lack of planning during the start of a project and cause of rework during the PLC
- Lack of effort in producing project-related documents
- Project delayed and bugs reported due to non-finalized SRS

The goal is to improve the project management – from project planning, gathering user requirement, preparing project’s technical and non-technical documents, project scheduling – to reduce the software bugs and rework effort. In doing so, this study will investigate the resource allocation as well as current project operational framework to improve project efficiency and effectiveness.

5.5 Improve Phase

5.5.1 Introduction

Upon completion of the Analysis phase, the team produced a list of possible actions and ideas to address the root causes are outlined in Table 61. The team shared the possible actions and ideas with the Managing Director and the shortlisted suggestions included ways to improve the chances of on-time software product delivery by adopting a structured and scientific approach of IT project management. The suggestions for improvement can be viewed from two broad categories: (1) Changing ways to improve software quality; (2) Suggesting ways to improve the efficiency and effectiveness of operational flow of project management as well as better resource managing, controlling and allocation among team members.

Table 61 Idea and Action Plan for SYNDES

No	Ideas and Actions	Responsible
1	Improve software quality by adopting a structured and proven scientific approach to IT Project Management	• Project Manager • Support Lead • Technical Lead
2	Introducing Project Organization Hierarchy Chart to foster power and authority distribution within the project team	• Project Manager • Support Lead • Technical Lead
3	Improve Current Operational Work Flow: • To better utilize scarce resourced so that the amount of rework can be reduced • From V-Model to W-Model to better utilized existing resources • Broadening the crossed-team knowledge sharing among support team and technical team	• Project Manager • Support Lead • Technical Lead
4	Introducing performance incentive for milestone accomplishment	• Project Manager
5	Adopting the use of control documents for better controlling, tracking and managing project's progress	• All Team Members
6	Adopting SRS as control document	• All Team Members
7	Proper project scheduling	• Project Manager • Support Lead • Technical Lead

Source: Case study analysis compilation

5.5.2 Improvement Action Plan (AP)

5.5.2.1 AP#1: Adopting Structure and Scientific Approach

The first action plan is to improve software quality by adopting a structure and proven scientific approach to IT Project Management. IT project management requires a "*structured and scientific approach*" to the practice of management in order to meet the myriad challenges of the modern era in the rapidly evolving IT industry. This is the main reason why the case company must take the practice of project management seriously. Without a scientific approach to the task of managing the projects and achieving objectives, it would be very difficult for organizations to successfully execute the projects within the constraints of time, scope and quality and deliver the required result [30]. In other words, there has to be a framework and a defined way of doing things to ensure that there is a structure to the art of project management.

Based on the recommended actions from FMEA, several process improvements activities were introduced in various the phases of the PLC. Table 62 shows the summary of the suggested project management activities particularly focusing in the phases of initiation, planning and execution. The SDLC is a process used by a systems analyst to develop an information system. It aims to produce high quality system that meets or exceeds customer expectations, reaches completion within time and cost estimates, works effectively and efficiently in the current and planned Information Technology infrastructure, and is inexpensive to maintain and cost-effective to enhance. In the existing planning phase, SRS was overlooked and only complied 40% of the overall user requirements. As a result, project schedule which benchmarked with brief SRS result in scope creep and rework towards the end of SDLC. The omitting of unit test plan has further triggered a drop in the software quality causing an increase of reported software bugs. Therefore, it is important to spend sufficient quality effort and time in planning a project.

Table 62 IT Project Management Life Cycle

No	Phases	Description	Responsible
1.	**Initiation**	**Develop a Business Case**	PM/PL, Business Lead, Technical Lead
		Undertake a feasibility study	PM/PL, Business Lead, Technical Lead
		Establish the Project Charter and appoint the Project Team	PM/PL
2.	**Planning**	**Develop a detailed SRS** • Understand and analyze SRS from end-user and technical perspective • Take ownership of the SRS • Review SRS • Changes to SRS should reflect in project schedule	PM/PL, Business Lead, Technical Lead
		Create a Project Schedule • Project schedule **MUST** map with SRS • Tasks or efforts more than 0.5D must be listed as an individual task • Schedule to include : weekly reviews, testing (QA & Unit Testing), preparation of unit test plan and QA test plan, brainstorming, code walk-through • Schedule team members to work on 6 hours per day instead of 8 hours per day • To review and agree upon the project baseline	PM/PL, Business Lead, Technical Lead
		Prepare Unit Test Plan, QA Test Plan and UAT Test Plan • Review Unit Test Plan, QA Test Plan and UAT Test Plan • Unit Test Plan, QA Test Plan and UAT Test Plan should map with items in SRS	Business Lead, Technical Lead
3.	**Execution**	**Prepare System Specification and Functional Specification** • Review System Specification and Functional Specification • System Specification and Functional Specification should map with items in SRS	Technical Lead
		Unit Testing and QA Testing Review Process • Ensure ALL unit testing and QA Testing are reviewed • Ensure the project role of the reviewer for unit testing and QA testing should be at least the same or higher than the role of the tester • Ensure crossed-reference of Unit Test Plan and QA Test Plan to SRS item	PM/PL, Business Lead, Technical Lead
		Update Project Schedule on timely base	PM/PL
		Periodic Project Progress Review	PM/PL
		Software Code Walkthrough	PM/PL, Technical Lead
		Configuration Management for Project Documents	PM/PL, Business Lead, Technical Lead
4.	**Project Closure**	Not within the scope of this study	
5.	**Project Completion**	Not within the scope of this study	

Source: Case study analysis compilation

5.5.2.2 AP#2: Project Organization Hierarchy Chart

An organizational chart is a diagram that shows the structure of an organization and the relationships and relative ranks of its parts and positions/jobs. Project management is the discipline of planning, organizing, securing, managing, leading, and controlling resources to achieve specific goals. It is always necessary for the project management team to follow a project hierarchy chart in demonstrating the distribution of power and authority within the project; showing respective contractual position, who is the leader and who is the team member. The project hierarchy chart will show the domain of every team member; team members require it so they know who to confront should conflicts or doubts arise.

The determination of the project hierarchy chart used is based upon the corporation's size and style [242]. Since SYNDES falls into the category of "Small Enterprise" with scarce resources, both flat and matrix organizational charts may not be suitable for SYNDES. The matrix organization management requires pooling people with similar skills for work assignments. This is not an option for SYNDES as there are limited resources and it impossible to share resources between different assignments. Since there exist high staff turnover in SYNDES, most staff are semi-trained and require close supervision by many layers of management; the practice of flat structure with few or no levels of intervening management between staff and managers is only ideal for well-trained workers.

The resulting outcome from the Six Sigma analysis phase allowed the team to plot the project role of SYNDES into the hierarchy chart in Figure 31. SYNDES's project hierarchy is led by both the Business Lead and Technical Lead. Both Team Leads are involved in the entire PLC with the objectives to broadening crossed-team knowledge sharing. Technical Lead with business knowledge will design and develop a product/service from the end-user perspective; whilst the Business Lead enhanced with valued-added technical knowledge would perform better in effort estimation and resource scheduling.

Source: Case study analysis compilation

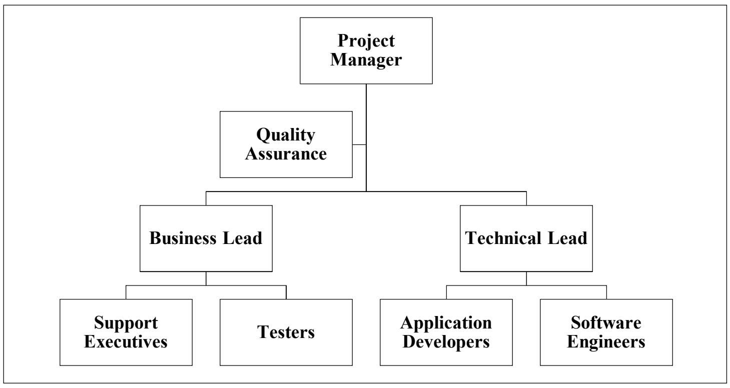


Figure 31 Project Hierarchy Chart – SYNDES Technology

5.5.2.3 AP#3: Current Operational Work Flow

SYNDES was funded since 2009 with two employees (inclusive of the Executive Director) and as the technology trends expanded into the field of WiFi, WiMax, GPS and GPRS; SYNDES has successfully secured projects from different business sectors ranging from retailer, construction developers, network service providers, insurance and financial, cosmetic and healthcare, electrical engineering and more. In the effort of maximizing existing resources performance, SYNDES has currently deployed and segmented its scarce resources in the manner as shown in Figure 32.

In Figure 32, it was observed that there are total of THREE groups (green, blue and pink) of full-time employee (FTE) involved in the PLC, with each handling different phases and at different time frame. Blue-team (i.e. blue dotted line) is the dominant group at the start of the project in System Analysis phase; as well as in the Testing phase.

During the System Analysis phase, analysis of user requirements will later be transformed into SRS. The Blue-team will then prepare the draft schedule to be used by Green-team and Pink-team as a baseline to benchmark in project scheduling and budgeting. Green-team consists of technical staff who carry the development responsibility in the execution phase where the product and service is actually “produced” or “developed”. Since the Green-team is the sole FTEs that know the complete architecture of the end product/service, they are the best candidates for deployment and implementation. On top of these two groups, there exists the Pink-team given the responsibility as “Software Quality Assurance (SQA)” for verifications of user requirements in SRS against the end product.

It can be observed that the current way of resource allocation is obviously lacking of FTEs continuous involvement in the PLC. The Blue-team which was assigned to gather user requirements are not involved in development phase. As a result, SRS information especially related to business-knowledge was not systematically documented and transformed into SRS. The next in-line group (Green-team) is executing the project solely based on individual assumptions and doubts from the aspects of client business operations and knowledge. Hence, the introduction of different teams handling different project tasks throughout PLC is indeed an unhealthy, inefficient and ineffective way of resource utilization.

According to Schwalbe [30], it is important to create awareness among the PM/PL about the importance to embark on ‘continuous’ client’s business and operational knowledge within the project team throughout the PLC. This ‘continuous’ effort is important to broaden crossed-team knowledge sharing among technical and support teams throughout different phases of PLC specifically for project durations which normally exceeds 3 months. Therefore, this ‘continuous’ effort is vital especially during the project startup where SRS is an iterative task where changes and updates are required to be completed before the start of the execution phase. By doing so, the team is producing “what suits the customer” but not “what the project team can do”. As a result, most of the completed tasks in the execution phase did not comply with SRS which led to further rework. The “finger-pointing war” was declared between the Blue-team and Green-team where “corrective actions” are needed in SRS processes, Database Design, System Core, System Integrator, System Interface as well as all the related system documentations and system specifications. The matter get worsens as the Pink-team only comes into the picture during the PLC when both coding and testing has completed. Another round of major modifications is expected which leads to further erosion of team morale. This ineffective and unproductive way of resource allocation has proven a failure when Project-B encountered 30% changes in SRS, 10 weeks of delays in project delivery and 100 high-impacting bugs reported.

Source: Case study analysis compilation

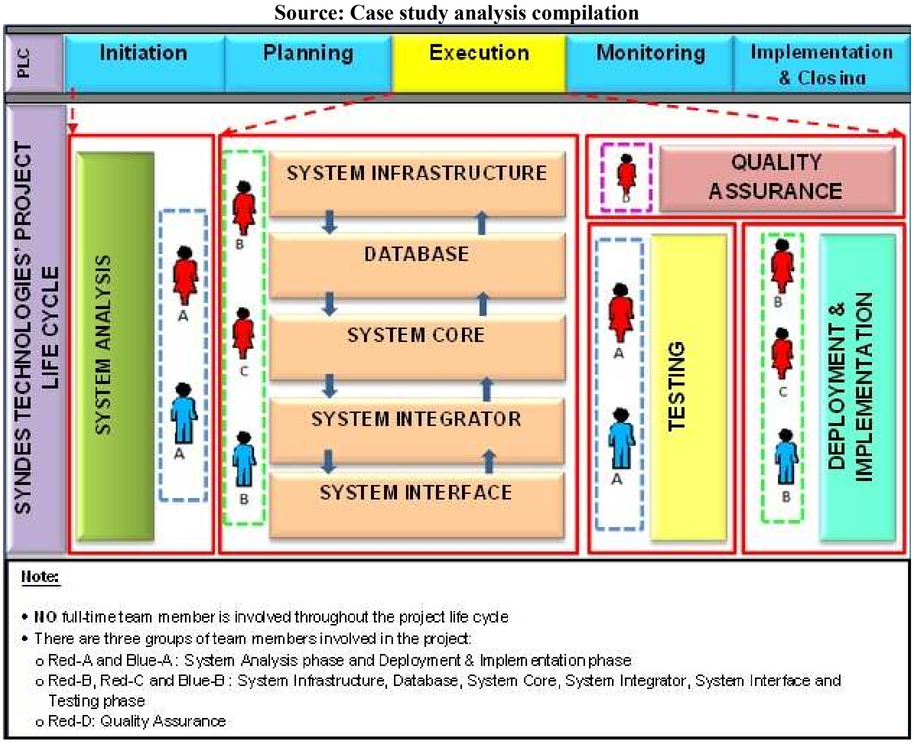


Figure 32 Existing SYNDES Technologies Project Resources Allocation [223]

5.5.2.3.1 AP#3a: Improve Current Operational Work Flow

In view of the importance of continuous business knowledge sharing among the team members from the start of the project initiation phases, planning phase, executions, maintenance phase and implementation and closing phase; it is always a productive measure having fixed or the same FTE involved from the start of the PLC towards project execution phase. In Figure 33, Blue-team (i.e. Red-A and Blue-A) are the two FTEs who are involved from the start of the PLC in gathering user requirements, project planning and scheduling, project development, testing, deployment as well as implementation. This way of “continuous” business knowledge sharing among the team members has indirectly eliminated task redundancies as well as assumptions in understanding client's day-to-day operational activities. As a result, rework is minimized, team motivation is encouraged and team morale is improved. These overall factors of impacts have a close relationship with work performance and work productivity. The project quality matters will be overseen by the same Blue-team and the QA staff (Red-D). QA responsibility should be a continuous effort too throughout the PLC; as a development task is made up of several smaller manageable tasks.

It is believed the V-model will improve the product/service delivery performance; at least shortening project delays and most importantly targeting to reduce quantity of high-impacted bugs. Despite the disadvantages discussed earlier, the V-model allows the flexibility of resource allocation between phases in the PLC. In the event where more resources are needed in the execution phase, SYNDES has the freedom to add-in any developer(s) either experienced or in-experienced; as the model has a minimum of ONE FTE (i.e. Red-A or Blue-A) who are aware of the overall project status and health. Even though an allocation of inexperienced team members does NOT burden or affect the project schedule, the assigned team members only need to carry out the task as specified in the system specifications or functional specifications. In short, transparency of staff dependencies has increased and the ability to have mobile team members among projects is much easier with little impact on overall project.

Source: Case study analysis compilation

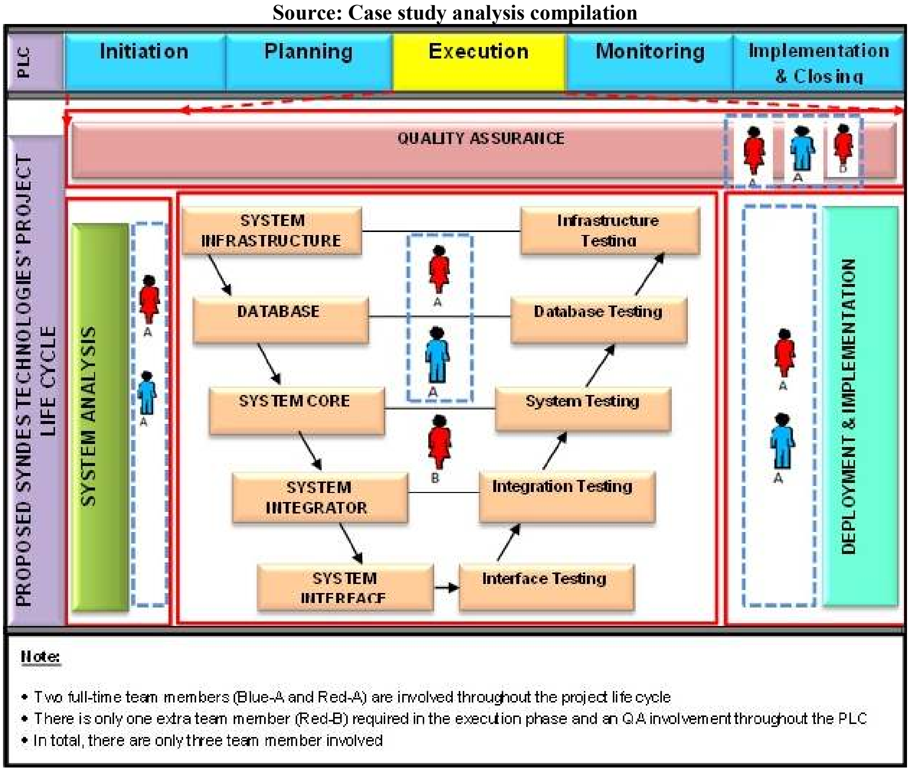


Figure 33 Proposed V-Model for SYNDES Technologies Project Resources Allocation [223]

5.5.2.3.2 AP#3b: From V-Model to W-Model

Despites the V-model's weaknesses in its rigidity, inflexibility and the expense in coping with scope adjustments, it is important to note that the V-model has evolved over time and supports flexibility and agility throughout the development process [243]. As such, the research team is proposing a W-Model, a model invented by Dr. Andrea Spillner, a German professor at the Hochschule Bremen [244]. The W-model was derived from the V-Model retaining the same advantages of the V-Model and thus providing the importance of testing and a clearer sequence of the individual activities for testing.

As an outcome from the week-long on-the-job observation from SYNDES's project, the research team has identified the following weaknesses of the initial SDM of the case company which need to be addressed carefully in the proposed model to minimize negative impact on end product delivery:

- Obvious business and technical knowledge gap between system analysis and execution phase
- Business knowledge acquired during system analysis are not shared throughout PLC
- Non-continuous staff allocation throughout PLC. Each phase is assigned with different group of resources.
- Team members perform tasks based on assumption

In view of the lack of "connectivity between phases", the *existing operational model of the case company can be customized and adjusted to V-Shaped* (Figure 33) *and then to a W-Model* (Figure 34). With the expansion of V-Model to W-model, there is no change to resources allocation, i.e. it is still the same Blue-team (Blue-A and Red-A) with an additional staff (Red-B) in the execution phase and a QA staff (Red-D) throughout the PLC. The W-Model attempts to address shortcomings in the V-Model. Rather than focus on specific dynamic test stages, the W-Model focuses on the development products themselves.

Essentially, every development activity that produces a work product is shadowed by a test activity. The purpose of the test activity is to determine whether the objectives of a development activity have been met and the deliverables meet its requirements. The respective testing phase parallel to the development process is carried out in a tighter sense. This is to ensure that output from each phase is validated before passing as an input to the next phase. In its most generic form, the W-Model presents a standard development lifecycle with every development stage mirrored by a test activity [241].

Source: Case study analysis compilation

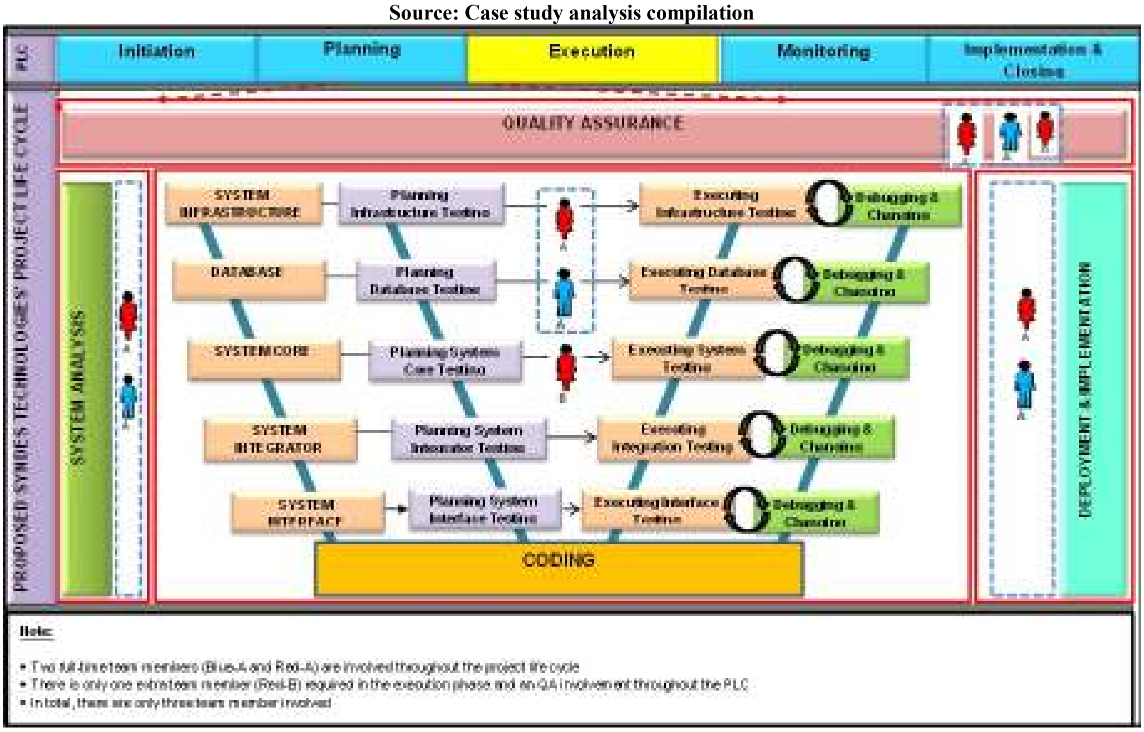


Figure 34 The W-Model for SYNDES Technologies [223]

5.5.2.3.3 AP#3c: Broadening Crossed-Team Knowledge Sharing

In order to further justify the efficiency and effectiveness of resource utilization with the proposed W-model, the team performed an analysis of team knowledge sharing among the available resources. Table 63 outlines the resources utilization and knowledge sharing between the current Software Development Model against the proposed W-Model. Since the customized W-Model is more effective and efficient in resources allocation and knowledge sharing as compared to existing SDM, the W-Model has three FTEs being 100% utilized and a developer/programmer is 33.33% involved in product development. Though this person (Red-B) is not 100% involved in the PLC, he/she is 100% involved in product development. In contrast, the existing SDM for the case company involved six persons where "all" are underutilized (5 persons with 33.33% utilization and 1 person with 16.67% utilization). None of the resource has full-time involvement in the PLC and this creates a "knowledge gap" and/or "non-continuous" knowledge sharing among team members, which further complicates the testing and QA activities. Rework arises as team members are required to "pick-up" project status midway and have a steep learning curve.

Table 63 Team Knowledge Sharing and Resources Utilization [223]

Current Crossed Team Knowledge Sharing and Resource Utilization						
Resources	**Planning**	**Requirement Analysis**	**Design**	**Testing**	**QA**	**Implementation**
Red-A (33.33%)						
Blue-A (33.33%)						
Red-B (33.33%)						
Red-C (33.33%)						
Blue-B (33.33%)						
Red-D (16.67%)						
Total Resources : 6 persons *** Resource Utilization: 5 persons 33.33% ; 1 person 16.67%**						

Proposed Crossed Team Knowledge Sharing and Resource Utilization						
	Planning	Requirement Analysis	Design	Testing	QA	Implementation
Red-A (100%)						
Blue-A (100%)						
Red-B (33.33%)						
Red-D (100%)						
Total Resource: 4 persons * Resource Utilization : 3 FTE 100% resource utilization ; 1 person 33.33% * Assumption: Resource Utilization is evenly shared across the phases of SDLC						

Source: Case study analysis compilation

It is often the case that many IT organizations go on for years misusing, underutilizing, or even over utilizing their resources. Therefore, it is important for the case company to achieve **optimum utilization of available resources**. This leads to efficacy in project management as the project manager could optimize the allocation of technical experts, business analyst in according to their skills, knowledge to avoid wastage. Besides, it is important to realize that there exist a minimum "cost" associated with the learning curve; and yet is unable to expect optimum performance from the team members. Therefore, it is always wise to keep "cost to learning curve" to minimum by strategizing available resources efficiently and effectively into projects.

5.5.2.4 AP#4: Introducing Performance Incentive for Milestone Accomplishment

In the context of project management, a milestone is a task of zero duration that shows an important achievement in a project [30]. It is a way of knowing how the project is advancing because it symbolizes an achievement, a point of time in a project. Milestone is an event that receives special attention because it is often falsely put at the end of a stage to mark the completion of a work package or phase [31].

Milestones often take several activities and a lot of work to complete. It is a useful tool for setting schedule goals and monitoring progress. Some suggestions of milestones for SYNDES projects include the following:

- Team member prepare key project documents of SRS, unit test plan, project schedule, UAT test plan, system specification, functional specification, user manual and more.
- Team member deliver a function, module, procedure etc. on the scheduled date.
- Customer sign-off key documents such as SRS, UAT, product delivery and etc.
- Mark the completion of "a" critical task which affects the whole schedule.

This study is proposing a milestone-based incentive in recognizing the accomplishment of "major milestone". Milestone-based incentive is a common practice for most IT organization in recognition of team member's effort delivering a "significant" task after a series of interconnected tasks. In the IT industry, completion of a "major milestone" normally involves a team; and the milestone incentive is commonly team-based too. It can come in the form of positive rewards event (e.g. a karaoke session, a fine dining, a sports tournament etc.) which is believed will enhance team spirit, team work and team motivation. A positive and motivated team is always the start of a successful project.

5.5.2.5 AP#5: Adopting Unit Test Form Document

Project documentation is used to define the way in which a project will be managed and the governance surrounding it [245]. Project documentation provides a useful memory aid to help ensure your proposal is relevant, engaging, authoritative, directional and yield optimized.

During the life cycle of a typical IT project, a project manager can produce up to fifty different types of documents to facilitate the planning, tracking and reporting of the project. Documents range from feasibility studies, resource plans, financial plans and project plans, to supplier contracts, post-implementation reviews, change request forms and project status reports. The fact is, the manner in which project documents are managed by project leaders can either be the driving force behind a project's success or the bottleneck that often places a project in despair resulting in its failure to meet its time line, budget and scope [245].

In view that the case company has adopted some project documents, the research team is proposing to formally adopt test plan and test form so as to track, manage and improve the testing activities. Currently, unit testing does not benchmark with test plan; it is a “free-style” testing without a test plan. This method of testing is aimless and indeed is a waste of time. All tested condition/scenario are not recorded, resulting in no reviews and no follow-up. The pool of testing outcomes is solely based on “trust” and “screen” which further complicates the QA testing. As a result, bugs and non-conformance of user requirement are captured during QA testing which is usually carried out just before the UAT test or product delivery. This is the critical moment where software is due for acceptance sign-off but is “not-fit” for delivery.

A test plan is a document describing the scope, approach, resources and schedule of intended testing activities. It identifies test items, the features to be tested, the testing tasks and who will do each task. Therefore, it is important and necessary to map each item in the SRS against test plan items. Unit Test form is a document proof that a unit test condition/scenario has been performed. The tester is required to fill in Unit Test forms for all test cases in the Unit Test Plan. All tested cases will be reviewed by a reviewer whose project role is more senior than the tester. For example, testing performed by a developer is reviewed by technical lead, system analyst, project manager, business lead or anyone who has sufficient knowledge and expertise to verify the performed unit test is valid. Any testing without review procedure is a waste of resource and time.

Table 64 is a sample unit test form. It outlines the steps taken to perform a test case, what is the expected result, how is that expected result, who tested it, who reviewed it and the status of the unit testing. The success of any project is crucially dependent on the documents produced for it and it is vital to ensure project documentation is short and sharp and make much more use of people-to-people communication. With unit test form bench marking the status of the project, the project manager can issue reports to stakeholders regularly and confidently.

Table 64 Sample Unit Test Form

Project Code : **Project Name :**	**Date :** **Ref :**
Steps :	
Expected Result :	
Actual Result :	
Tested by :	
Reviewed by : **Comments :**	**Date :**

Source: Case study analysis compilation

5.5.2.6 AP#6: SRS As Control Document

SRS is a control document of baseline *user requirement* established during the Planning phase and is used by the project team for planning and execution. The project team will plan, schedule and develop the end product based on the "criteria" defined in the SRS. SYNDES should adopt SRS as a control document; a good SRS should give the project team a "detailed" understanding of the project scope, outlining what are the expected deliverable items, modules, functions, products, services and supports. Items in the SRS are normally being referenced in the scheduling process to estimate total time, cost and resources needed to develop "these" deliverables. Therefore, it is necessary to pay closer attention to the SRS to minimize the chances of scope creep.

5.5.2.7 AP#7: Project Scheduling

Items in the SRS are the main source or input for project scheduling [124]. Hence, it is important to break down items in the SRS into smaller and more manageable items so that mapping of SRS items against project schedule can be carried out more effectively and efficiently [30]. In the event that the SRS items can be segmented into independent module(s), modular delivery by stages is recommended. Whenever items in the SRS are being itemized and mapped into respective "smaller manageable task" (i.e. tasks with more than one man-day effort must be listed as a separate task) in the project schedule, the project team manager needs to ensure all items in SRS are taken care of with entries into the project schedule. As a result, at any one time the case company only requires to maintain project schedule (i.e. which was mapped with SRS items) [30, 31, 218] and the next focus would be tracking, controlling, developing and delivering "these" SRS items in the project schedule.

5.5.3 Six Sigma Implementation Outcomes

In order to investigate the effectiveness and efficiency of the proposed action plans in Section 5.5.2 as a result of Six Sigma implementation, SYNDES adopted and applied the customized W-Model on two projects (Project-X and Project-Y). Project-X is a software extension (Phase-II) of Project-B and Project-Y is a new project where the research team benchmarked these two projects achievement against the basis of eight projects. Project-X kicked off in February 2013 and Project-Y was initiated in October 2012. Following adoption of the W-Model, the case company assigned a full-time business lead and a full-time technical lead throughout PLC for both projects. Additional technical staff is assigned (i.e. Project-X with one FTE; Project-Y with two FTEs) during the product development phase to ensure and transform business ideas into viable system.

In view of the nature of Project-X (Phase-II of Project-B), the project was segmented into five independent modules with each delivered at different stages of the project execution phase. To-date, all the five modules are delivered on-time and in compliance to SRS specifications. Although there are bugs reported after modular delivery, there is a significant improvement of total sigma level in high-severity software quality defects. Project-X demonstrated a great improvement in software quality defects where there have been no high severity bugs reported as compared to 100 out of 129 reported previously. Although there are 23 low severity bugs reported, those bugs fell into the category of "cosmetics" rectification where fixing was straight forward and a minimum of re-testing was required. The adoption of the Six Sigma design/redesign approach in the case company has improved the deliverables quality by 82.17%, with a lower numbers of total bugs reported (total 23 reported bugs as compared to 129 prior to Six Sigma adoption). Furthermore, all the five modules were delivered on-time, within-budget and met project scopes. Table 65 summarized the project performance of both Project-X and Project-Y after the adoption of Six Sigma into its' project life cycle; which was benchmarked against Project-B and Project-E (i.e. before Six Sigma adoption).

Table 65 The Operational Definition for Project-X and Project-Y – SYNDES Technologies

Project Status	Benchmark (Before Improvement Phase and before Six Sigma adoption)			Improvement Phase (After Six Sigma adoption)	
Projects / Operational Definition	Web-Trac Revamps % Upgrade (Phase-I) - B Jan 2012 – July 2012	Pregnancy Journey Portal - E July 2011 – Dec 2011		Project –X Software Extension (Phase II) of Project B Feb 2013 – May 2013	Project –Y DOS to WIN Hire Purchase Conversion October 2012 – May 2013
Project Duration	20 wks or 100 days, 3 FTE	16 wks or 80 days, 2 FTE		20 wks or 100 days, 2 FTE	6 months or 24 weeks, 2 FTE
Changes to baseline SRS	□ 5% - 10% □ 10% - 20% □ 20% - 30% ■ **30% - 40%**	□ 5% - 10% □ 10% - 20% ■ **20% - 30%** □ 30% - 40%		■ **5% - 10%** □ 10% - 20% □ 20% - 30% □ 30% - 40%	■ **5% - 10%** □ 10% - 20% □ 20% - 30% □ 30% - 40%
Project Delivery Status	□ Ahead of time □ On-time ■ **Delay** **6 wks or 30 days, 3 FTE**	□ Ahead of time □ On-time ■ **Delay** **4 wks or 20 days, 2 FTE**		□ Ahead of time ■ **On-time** □ Delay	□ Ahead of time ■ **On-time** □ Delay
Code Walk Through	■ **Yes, brief** □ No	□ Yes ■ **No**		■ **Yes, detailed** □ No	■ **Yes, detailed** □ No
Frequency/Effort of QA Testing	Expected : **3 times** Actual : **1 time**	Expected : **3 times** Actual : **1 time**		Expected : **3 times** Actual : **3 times**	Expected : **3 times** Actual : **3 times**
Existence of Unit Test Plan	□ Yes ■ **No**	□ Yes ■ **No**		■ **Yes** □ No	■ **Yes** □ No
Reported Bugs (High, Medium, Low)	H : **100** M : **20** L : **9**	H : **2** M : **3** L : **6**		H : **0** M : **0** L : **23**	H : **0** M : **0** L : **20**
Project Review	□ Formally ■ **Informal**	□ Formally ■ **Informal**		■ **Formally** □ Informal	■ **Formally** □ Informal

Source: Case study analysis compilation

The importance of up-front planning in IT project management has been proven in Project-X, showing 20 days effort (against 1 day planning effort in Phase-I) in project planning has resulted in better SRS management, less rework (only 5% as compared to 15% in Phase-I) and more manageable bugs (no high severity bugs as compared to 100 high-severity bugs in Phase-I). The success of up-front planning also yielded other positive practices such as producing a detailed SRS, mapped SRS items into project schedule, all tasks in project schedule having less than or equal to one man-day effort and aided preparation of a comprehensive test plan and testing to be carried out in all phases not limiting towards the end of project execution.

In summary, Project-X and Project-Y reported with improved resources utilization of the business lead and technical lead to 100% as compare to 33.33% previously. Quality Assurance Testing is now a continuous task throughout the PLC; not limited to the end of the PLC. To-date, only 5% (i.e. 3.145σ) SRS changes was reported in Project-X as compared with 40% (i.e. 1.753σ) in Phase-I; showing an improvement of 87.5%. Similarly, Project-Y only required 6% (i.e. 3.055σ) changes to SRS as compare to an average of 24% (i.e. 2.206 σ) in the past (based on historical data of 8 projects). Most importantly, the adoption of the customized W-Model allows the project team (business lead and technical lead) to have a hands-on approach with project sponsors and they are in a better position to deliver an end product which fits the sponsors' business needs. As a result, the case company has established a highly motivated project team, who are reliable, responsible and trustworthy in handling the entire project. Several performance incentives in the forms of fine dining, electronic gadgets, movie tickets, extra day-off etc. are awarded to team members of Project-X and Project-Y upon milestones accomplishments.

In particular, the adoption of the W-Model allows the management team to spend more time (60% as compared to 30% in the past) exploring business opportunity locally as well as regionally. Other positive project implications as a result of better resource utilization are:

- The gap between business knowledge and technical knowledge among the business and technical leads has been reduced. The Business Lead is now capable of handling some technical issues confidently and independently; and vice versa for the technical lead.
- All user requirements are carefully analyzed and recorded into the SRS which was mapped into the project schedule. The team handling the SRS is the same team executing the SRS. A sense of ownership was established among the project team which further cultivates team motivation.
- As an initiative of continuous improvement, the achievement of team productivity has increased by 50% due to better controlling and better organization of IT project management activities. In return, better team motivations and team spirit was embedded into the case company's team culture where sharing of knowledge among technical teams and support teams will further improve project health.

5.6 Chapter Summary

The success of an IT project relies on a blend of demanding conditions. Those conditions are always worthwhile reviewing before and during the course of a strategic IT project. Careful and effective planning with Six Sigma design/redesign adoption ensures that projects will not overrun deadlines and pile on unexpected costs. The greatest reason for project failure is lack of planning, so the ability to build and manage a project schedule is a top priority if one needs to succeed at any IT project.

In the world of IT, handling defects and problems in software development projects is a difficult task. Most of the time, organizations may ended up making bad decisions and problems are left unsolved; or it can even be aggravated by rework, employees become de-motivated and there is a lack of work satisfaction. Many companies have spent a huge amount of their budget on finding, and adopting a software development methodology that can improve its product, service or process quality. Therefore, the case company inevitably places great emphasis on managing quality as its needs to focus and direct its resources, money and time on a software development methodology which drives operational excellence.

The proposed of W-Model is by no means a substitute for sound project management but rather as a guideline which best suits the case company with its limited resources. The W-Model has its advantages and disadvantages too; and it is always worth remembering that newer methodologies draw on those that came before them. This improvement in resource allocation is proven and demonstrated by coupling Six Sigma DMAIC approach into the SDLC of a project life cycle. This success should be viewed as a continuous effort especially if there exist a change in business directives, resource volume and level of project hierarchy. As a means of continuous improvement initiatives, Project-X and Project-Y will be monitored throughout the PLC to ensure the effectiveness and efficiency of W-Model in coping with limited-resources.

Chapter-6 Case Study: IS Support UNMC

6.1 Introduction of Information Services (IS) Helpdesk Support of UNMC

The University of Nottingham Malaysia Campus (UNMC) is a truly international university with a diverse and vibrant community where faculty, staff and students from around the world collaborate in an environment that fosters world-class teaching and research.

Just like any other businesses and consumers, computers are necessary for UNMC completing daily activities or important functions, and when technical problems occur, a quick solution is necessary to avoid disruption of professional or personal business. Helpdesk Support is one of the resources available to help correct technical problems encountered with computers [246]. UNMC has initiated the concept of Information Services into the university's strategy, missions and goals. Internal helpdesk Support is part of UNMC providing support for employees, students and guests who need assistance, help or encounter problems related to learning process, company level operational routines etc. Helpdesk Support of UNMC is a service that takes incoming phone calls, emails or walk-in request via Front Desk or in-person about technical requests, problems and services that a person is encountering with a computer, a software program or a peripheral like a printer or scanner.

The Information Services vision is of a knowledge-enabled University where staff and students are actively supported to create, manage and exploit information in a flexible, user-led environment. This means that information and expertise is available to them at the time, in the place and in the format they need, dynamically supported by technology-enhanced collaboration and communication tools. Information Services' mission is to deliver high-quality information and technology services to support the research, learning, teaching and business activities of the University.

The role of Information Services is to lead information and technology strategy development for the University of Nottingham Malaysia Campus and to provide services, resources and infrastructure that enable staff and students to exploit information and technology in all academic and business activities, providing the highest standards of customer care. The strategic objectives of IS Helpdesk are: (1) To support research, knowledge transfer and commercialization ; (2) To enrich the student experience ; (3) To advance internationalization ; (4) To underpin communication and collaboration ; (5) To enhance the infrastructure ; (6) To lead on innovation ; (7) To integrate our management information systems ; (8) To offer expertise ; (9) To improve our working practices and (10) To promote service excellence.

The case study company is a Helpdesk Centre providing IT services that takes incoming phone calls, emails, web-form or walk-in request on technical related issues or services that a person is encountering with a computer, a software program or a peripheral like printer or scanner. The role of the Helpdesk Centre is to lead information and technology strategy development to provide services, resources and infrastructure that enable internal and external customers to exploit IT in all aspect of business directives and provide the highest standards of customer care. The case study company adopted a **Helpdesk Management System (HMS)** to process and manages helpdesk tickets and delivers a comprehensive platform to manage its customers' (internal and external) expectations.

Over the years, the role of HMS has evolved to not only focus on ticket management and ticket tracking, but has extended to knowledge management using a pool of problems resolutions which act as a platform for decision making to the management team, now and for the future. Most importantly, the knowledge-base and solutions built over time enable the team to be more efficient and effective in handling tickets without losing productivity on repetitive queries; making first call resolution a reality. The adopted HMS employs a multi-tiered trouble shooting approach by having personnel with extensive technical knowledge; the bottom line is, the case company aims to meet the most important needs of its end-users (e.g. staff, customers and guests) as well as for the helpdesk center to link into strategic areas within the company in meeting current and future strategic goals.

In the Helpdesk Center, IT requests/services are captured via Front Desk and Emails. The Front Desk officers are responsible for phone calls, walk-in requests and IT-related services. All attended front desk requests/services are needed to be updated into HMS by the front desk officers. These valuable data acts as an input to HMS in building a knowledge-base which can later be retrieved through intuitive real time reports and dashboards showing the actual performance of the helpdesk support team. With the pool of centralized raw data, HMS is capable of monitoring and managing the overall performance indicators of the helpdesk team such as: peak hour of the day/week/month of the year; the overall resolution rate of respective staff; staff utilization; total unresolved (opened) tickets, speed of resolution by categories, service level agreement (SLA) type, status etc.

All IT requests/services via emails will be monitored and managed by the Helpdesk Support team; and Front Desk officers are part of the team. The objective of this Six Sigma case study is to attain a better understanding of the routine **front desk** operational activities and its processes efficiency through a customary planned measurement and data collection to identify improvement priorities for the front desk management system.

In general, the data captured by the IT Front Desk can be categorized into five core areas (Table 66): User Account (e.g. username and password retrieval, reset etc.), Audio/Video (AV) (e.g.

equipment and application that deal with sound and sight in conference/meeting/training room), Wireless Access (e.g. wireless setup for laptop, smartphone, intelligent touch pad, gadget and etc.), E-Learning (e.g. providing IT-assistance to customers on E-Learning matters) and Other Requests/Services (e.g. networking, installation and etc.).

Table 66 IT Services By IS Support (UNMC)

No	IT Service	Description
1	**Computer Rooms**	IS manages a number of computer rooms offering PCs with network access, printing, some with 24/7 access, open to all staff and students of the University.
2	**Email and Storage**	IS assigns email and storage on the network for every staff and student. This is to ensure secure protocols for sending and retrieving mails, and extensive spam-filtering are implemented. Access to emails is made easy through a web-based interface.
3	**Portal and Workspace**	The University Portal provides students easy accessibility to relevant information such as personal details, access to past-year examinations, reading lists and examination results. Workspace is an online collaborative portal that allows staff and students across the university to share information, news and documents.
4	**Print, Copy and Scan**	The print, copy and scan services are available in IS computer rooms and the library. It uses your University Card or your University username to store credits which you can charge up at the library circulation counter. Scanning is free of charge.
5	**Software and PC Services**	IS provides hardware & software support for all University IT assets which includes procurement, maintenance, licensing and disposal. The University provided Windows-based computers are equipped with various software to fulfill the requirements of different schools and departments.
6	**Video Conferencing**	Video Conferencing allows face to face communications and meetings to be conducted with remote parties through the Internet or via digital telephony. There are suites across the University's UK, Ningbo and Malaysian campuses.
7	**Virtual Learning**	E-Learning materials are created and delivered through Virtual Learning Environments (VLE). VLEs help to facilitate course management, collaborative group projects, self-test exercises and online assessments. The University VLE is provided by Moodle.
8	**Wireless Access**	Wireless access is available for mobile devices via wireless access points installed throughout the campus. Staff and students can connect their mobile devices to the Internet using their University username and passwords. Guests of the University are to contact IT Helpline for temporary access.
9	**Others**	IS also provides Student Network Service, Audio Visual Equipment, Video shooting & conversion for academic purposes, IP Phone Services, Laptop and projector loan, Purchasing of IT Equipment, Business System Support, Website Support, New student & staff induction etc.

Source: Case study analysis compilation

6.2 Define Phase

HMS is a platform for IT staff capturing daily Helpdesk Support Services. All IT staff are required to update respective attended requests/services into HMS where tracking and follow-up can be managed and controlled more effectively and efficiently cross a single database. The collective pool of information from helpdesk can be used to analyze patterns and trend of customers' needs and habits. The key to technology helping a company is keeping IT functions available and operational-focused for decision use as much as possible. It is not possible to have 100% operational up time, but the aim is to ensure IT Department benefits from money invested into HMS. The one very valuable and single solution is: "The IS Support Team maximizing usage of the HMS in managing, tracking, handling and controlling all IS Support Services".

6.2.1 Introduction

In UNMC, Helpdesk is implemented in many ways. The bottom line is, Helpdesk should meet the most important need of the end users (e.g. staff, students and guests). In addition, by following the best practices, the Helpdesk will enable UNMC to have a foundation for IT department not only to meet the needs of the end user, but for the IT department to link into strategic areas within the faculty. Thus, the Helpdesk will be one component in enabling UNMC to meet their strategic goals in the information age industry.

The key objective in the Define stage is to create a clear understanding of the most critical cross-functional activities in the front desk, and how it interferes with internal and external customers. A preliminary analysis on the procedure and process flow of Helpdesk Support activities were collected via semi-structured interviews with Senior IT Manager, Team Leader of Customer Service Team, Helpdesk Support Officers as well as Front Desk Support Officers.

A preliminary analysis on the procedure and process flow of IS Support activities were collected via research methodology of interviews. The initial understanding of IS process flow begun with interviewing the following IT personnel:

- Mr. Lotus Ong, Senior Manager of the IT Department. Mr. Lotus Ong is responsible for overall operational activities for the departmental within the university campus which covers infrastructure, learning portal, helpdesk, networking, printing etc.
- Ms. Vivi, a Senior Executive to UMNC IS Helpdesk Support. Ms. Vivi oversees daily IS Support activities within the IT Department with the aid of a Helpdesk Management System.
- Front Desk Officers

6.2.2 Summary of Interviews

6.2.2.1 Interview with Senior Manager

An interview with Mr. Lotus was scheduled on 24th August 2012. The interview kicked start with brief introduction on different types of IS Services provided by the IT Department. There are about 30 staff in the department with each assigned and responsible to one (or two) IS Service(s). Majority of the IS Services requires special knowledge, training and expertise prior performing the job. Therefore, most IS Services are staff-assignment dependency and in general, IT staff are lacking in crossed-services expertise. As such, it is difficult to swap resources amongst IS Services and re-allocation among IT staffs seems quite impossible.

The general overview of IS Helpdesk Support operational activities can be viewed from two platforms: Front Desk and Email. Front Desk is responsible to all IS Service related requests, services and problems through walk-in and phone calls. Besides, students and staffs can seek IS Support assistant via email communication to general IS Support account (ITServiceDesk@nottingham.edu.my). Like any other IS Support Helpdesk, UNMC IS Helpdesk Support recorded all attended IS Support Services activities into a Helpdesk Management System (HMS).

Over the years, IS Helpdesk Support has been seeking ways to improve IS Support Services especially the internal operational flow. Mr. Lotus highlighted the concern to look into Front Desk IS Helpdesk Support as helpdesk is the university end users' operational "first aid" where attention and assistant should be given as quickly as possible. Besides, front desk support is the "first and only" place where students and staffs seeking help upon on IT-related matters.

According to Pande at al., [152], the following summary concluded from interviews justified and qualified the **Front Desk Helpdesk Support** as a Six Sigma improvement project:

- Although the front desk operational guide has outlined detailed activities/tasks needed to be performed by front desk officers, there still exists a gap between current and desired/needed performance.
- The IT management team suspects some reasons for such a "gap" but want to know and understand the real root-cause.
- To-date, there is no significant effort being launched to bridge the "gap" and currently there isn't any predetermined solution nor is the optimal solution apparent.

6.2.2.2 Interview with Front Desk Officer

In order to understand the daily operational front desk work flow, Ms. Ira was interviewed on 5th September 2011. Ms. Ira shared the challenges during the registration week (registration week is the week where new student enrollment takes place) especially in the main intake in September. New students will formally register as a student whereas returning-students registering for new semester. This is the time where variety of events, talks, seminars etc. are held centrally by respective faculty to orient and welcome new students. Events and activities are scheduled simultaneously cross different venues during the week of induction into university life and facilities.

During the registration week, front desk is usually packed with crowds at different time. There are long queues of requests/services from new students seeking assistance from front desk officers. In order to cope with the crowds, it is important to "clear" the crowds by attending soonest possible to request/service and providing solution. Normally, the crowd scene would stay for few days and thereafter it will be back to norm. In contrast during the off-peak period (i.e. non-registration week), front desk activities are much manageable.

Following are the summarized front desk work flow (both walk-in and call-in) gathered from Ms. Ira:

- For walk-in request/service, students and staff would line up and seek help from front desk officer. For all incoming calls to IS Support general line, 03-8924 8199 (ext. 8199), front desk officer will attend to them. In the case if front desk officers are attending request/service, other support team will help.
- Depending on the type of IS Services, student and staff will be prompted over the front desk counter with necessary information (e.g. username, student-ID etc.) in order to proceed with request/service.
- If the request/service is within the knowledge and areas of expertise of the front desk officer, he/she will perform the task on the spot. When front desk officer completes the request/service, the attended request/service will be logged into HMS.

- If the request/service is not within the knowledge and areas of expertise of front desk officers, he/she will log the incident with student information (from Student-ID card) and route to a staff who can take on this task.
- Respective staff is respectable for attending their own call-logs.

The interview with Ms. Ira summarized that front desk officers are aware of front desk work routine. There would be time where "some" attended request/service are not logged into HMS due to no follow-up is needed and has solution provided before student or staff leaving front desk. Ms. Ira will try her very best to capture all attended request/service into HMS.

6.2.2.3 Interview with Helpdesk Support Manager

Ms. Vivi is the IS Helpdesk Support manager oversees the UNMC IS Helpdesk. The interview with Ms. Vivi took place on 11th September 2012. Ms. Vivi is responsible to all IS Support Services via the help of HMS. The team was informed besides seeking help from front desk, students and staff could seek help from IS Support remotely via email without having physically appeared over front desk. Upon receiving email via IS Support account (ITServiceDesk@nottingham.edu.my), front desk officers require to perform service request routing manually. If a helpdesk service request's category is network related, front desk officer will route the call-log to network expert. If the category falls into Moodle/Portal, the call-log will be assigned to Moodle/Portal expert. Alternatively, the first-level support can be re-route to front desk officers. Every helpdesk support officer is fully responsible for their call-log.

Ms. Vivi revealed there is room for improvement for front desk services especially during big crowd. Ms. Vivi is aware that there exists a gap of capturing attended front desk call-log into HMS. This happens not only during registration week, but off-peak period too. Ms. Vivi hope that "The Six Sigma Way" will improve current front desk support by better handling and managing attended request/services into HMS.

6.2.3 Identification of Core Processes, Support Processes and Key Customers

As discussed in the earlier section on different types of IT Services in UNMC, the core processes of IS Support can be categorized into Computer Rooms, Email and Storage, Portal & Workspace, Print, Copy & Scan, Software and PC Services, Video Conferencing, Virtual Learning, Wireless Access and Other Services (e.g. Student Network Service, Audio Visual Equipment, Video shooting & conversion for academic purposes, IP Phone Services, Laptop and projector loan, Purchasing of IT Equipment, Business System Support, Website Support, New student & staff induction etc.). The standard processes that provides key resources or capabilities that enable the core processes to perform are the **support processes**.

The business nature of IS Support for UNMC is heavily resource-driven and IT-focused; the support processes are closely related to EMS (Education Management Information System), IT Specialist (e.g. System Engineer, Technical Support Executive, hardware and software (i.e. internal or external)), IT Infrastructure (i.e. WiFi, WiMax, Internet Access etc.), Process (formal and informal), QA (formal and informal) as well as finance and strategies in supporting all the core processes.

Source: Case study analysis compilation

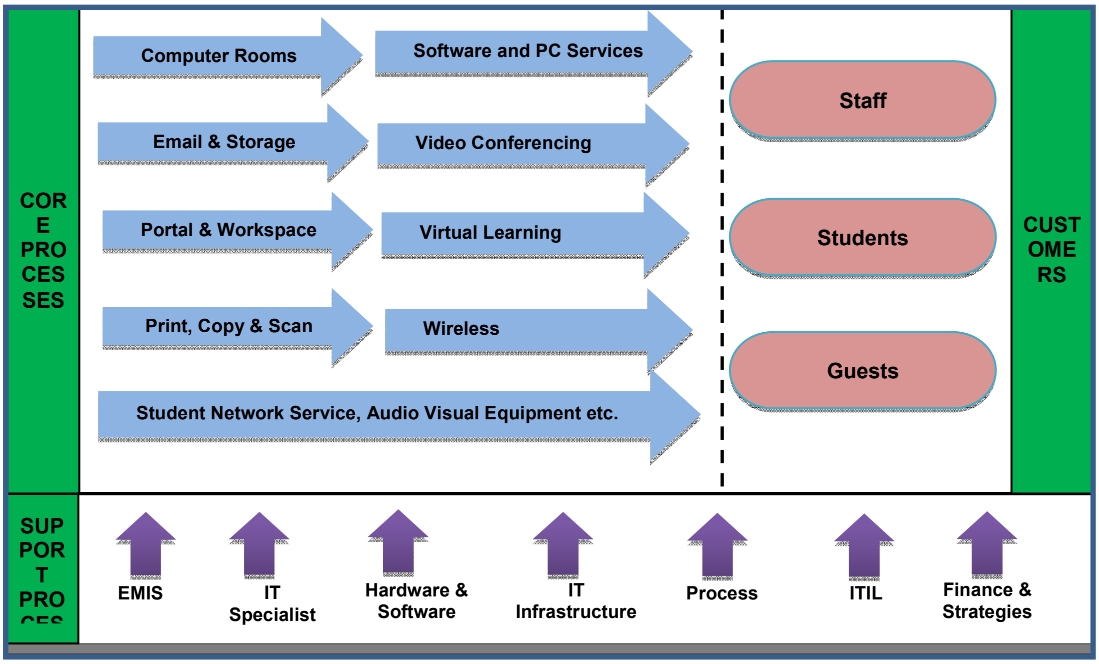


Figure 35 Overview of IS Support Services – Core Processes, Support Processes and Key Customers (UNMC)

It is important and necessary to identify the key customers for IS Support of UNMC in order to deliver appropriate services and requests; to maintain a good relationship with end users fostering customer relationship management and stay competent among IT services from other world class universities. Since IS Support is an internal helpdesk within UNMC, the key customers of IS Support are mainly focusing on students, staff (e.g. professors, associate professors, lecturers, teaching assistant, researchers, operational executive, management executives etc.) and guests. In general, Figure 35 shows the overview of IS Support Services Core Processes, Support Processes and Customers.

6.2.4 Information Flows Between IS Support and EMS

The core processes and support processes of UNMC IS Support Services can be viewed from the broader picture of Student Registration Process. The main information flow started with student registration where student information is stored and kept in Education Management Information system (EMS). By definition an EMS is an organized group of information and documentation services that collects, stores, processes, analyzes and disseminates information for educational planning and management [247]. EMS is a tool that uses systems theory, together with developments in computerization, to create a comprehensive approach to the collection and use of vast quantities of information on the education and training system. As the potential users of data, managers are systematically provided with accurate and timely information so that decision-making, planning, project development and other management functions and operations can be carried out effectively.

The main purpose of an EMS is to integrate information related to the management of educational activities, and to make it available in comprehensive yet succinct ways to a variety of users. These include teachers, principals, curriculum planners, inspectorate officials, financial controllers, planners, policy advisers and political leaders, as well as parents and students. In this way, the combined information resources of the EMS are at the service of the entire community. During the registration period, the department of Sponsorship, Admission, Finance, Security, IS Support and Accommodation Office are required to be stationed at the designated hall. Firstly, students with offer letters will proceed to the Verification counter where the originality of course offer letter will be verified and relevant certificate(s) stored into database will be certified against original copy.

Secondly, students with verified document can now proceed to course registration which is handled by the finance department and admissions office. When documents are valid and ready, students will register with the course offered, upon making registration payment, a receipt will be generated with assigned Student-Id generated from the EMS. All registered students' details are stored into EMS which later necessary information will be downloaded to IT Department, Library and Finance Department. This is to avoid data redundancy on Student-ID being shared among various departments and faculty. Upon registration, a registration pack will be distributed. The registration pack contains information about accessibility to library, accommodation office, email, computer lab, printers, network, WiFi connection etc. which in deed useful especially for freshman.

Thirdly, students with valid official receipt required to perform photo taking at the Security Department for Student Identification Card purposes. It may take a week or two to have the ID card ready for collection. Next, student may seek help from the accommodation office if accommodation registration is required. Any student requires financial assistance can proceed to the Sponsorship Unit. Lastly, student is required attending induction program by respective course department. When all the "formal" registration is completed, it is the time for username and temporary password retrieval for campus wide network access and email activation.

All the core processes of IT Service are authorized with username and password generated from EMS. IS Support will only precede key customers' requests with valid Student-Id assigned from the EMS. A valid Student-Id enables *every* student retrieving respective username and password.

This can be done by activating assigned Student-Id over UNMC Email website (http://www.nottingham.edu.my/username). Once respective username and temporary password is retrieved, student can enjoys all IT Services provided by the university. The overview of how Student-ID is generated during student registration process is outline in the following diagram of Figure 37.

6.2.5 IS Helpdesk Support Management Process

Figure 36 shows an overview of IS Helpdesk Support. IT requests/services are captured via Front Desk and Emails. Front Desk is responsible for phone calls and walk-in requests and services. All attended front desk requests/services will be updated into HMS by the front desk officers. Requests/Services from Emails (ITServiceDesk@nottingham.edu.my) will be monitored and management by the IS Support team. Front Desk officers are part of the Helpdesk Support Team. The objective of this Six Sigma case study project is to provide better understanding of the front desk operational activities routines, the processes, but also solid information on improvement priorities for better front desk management system. The research team is focusing on the red dotted of the HMS.

Source: Case study analysis compilation

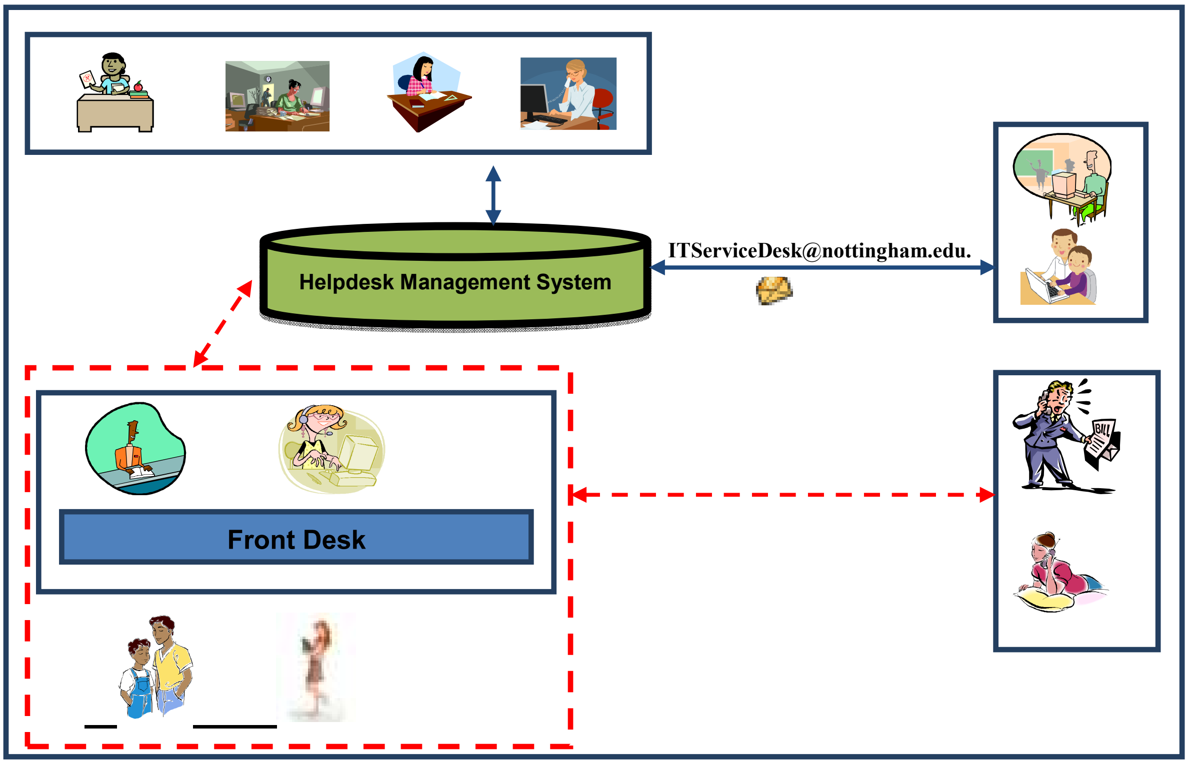
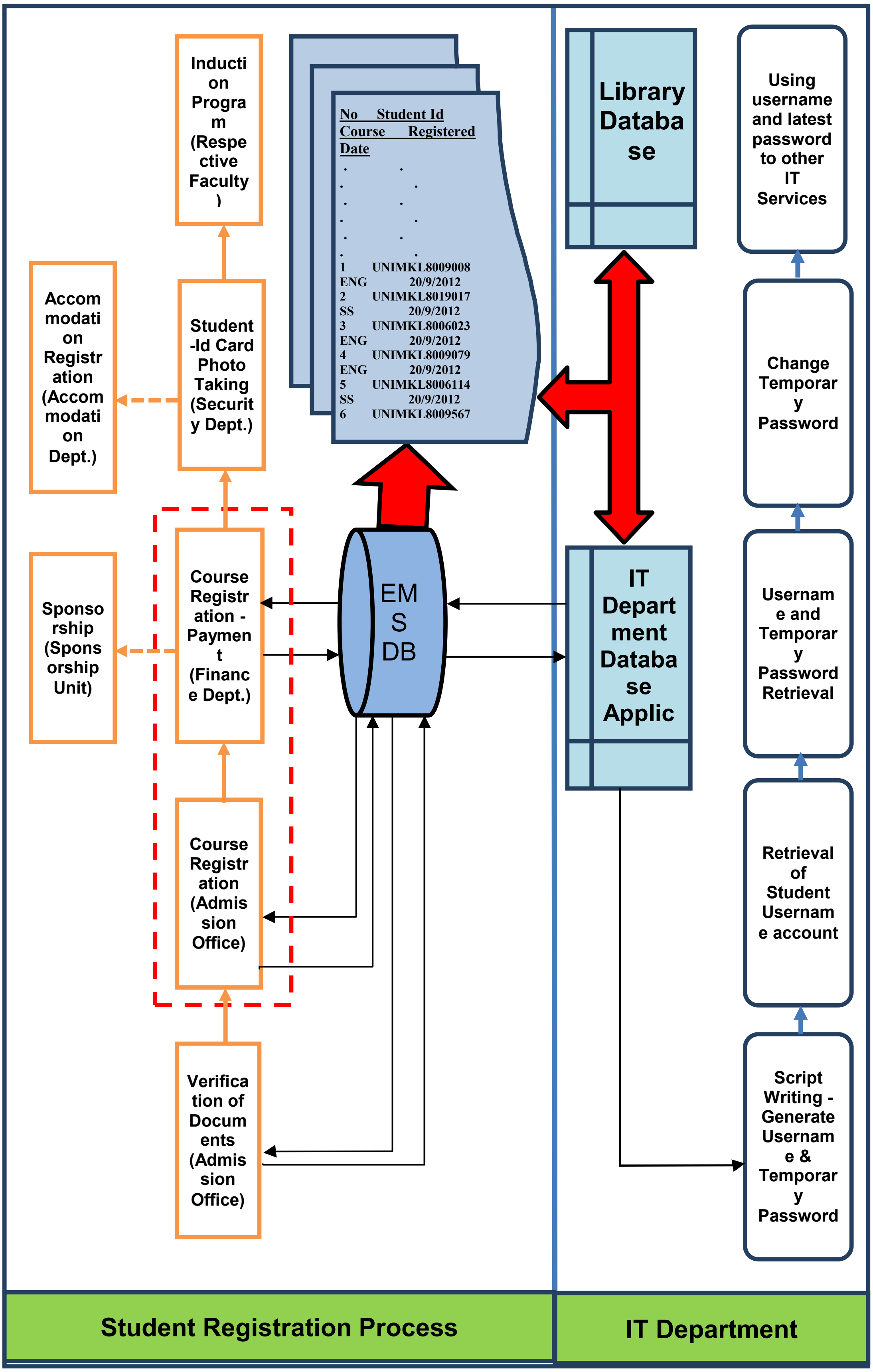


Figure 36 Overview of IS Helpdesk Support (UNMC)

Figure 37 Student Registration Process (UNMC)



Source: Case study analysis compilation

6.2.6 Identification of Critical-To-Quality and Voice-Of-Customer

One of the challenges in measuring the performance of any support team is to create a meaningful view of performance. Although it is not possible in a single chart to capture all of the facets of performance, there is one chart that provides a great monthly performance dashboard. The first step in creating Service Level Agreements (SLA) or Service Level Objectives (SLO) is to create a service catalog. At its most basic level, a service catalog is a list of all the services your helpdesk will provide. In most cases, an SLA is used to define the support requirements of a team to which the helpdesk escalates cases.

There are many published academic and business reviews about how Six Sigma has dramatically improved the quality of products and services (e.g. GE, Allied Signal, Motorola, and Amazon.com.) Six Sigma is a perfect fit for Helpdesk [248]. If any helpdesk is not meeting their customers' expectations, Six Sigma can help to make measurable improvements. The SIPOC diagram for IS Support Helpdesk is outlined in Figure 38. Once the overall picture of IT Front Desk operational activities mapping is established; the next step is to identify Critical-To-Quality (CTQs) shown in Table 67:

Table 67 CTQs Measure for IS Front Desk Requests/Services [249]

No	CTQs	Output Measures	Input/Process Measures
1.	Front Desk User-Account Call-Log Capture Defect	Number of non-captured User-Account requests/services via front desk	Discrepancies between manual counting on front desk User-Account related requests / services against HMS.
2.	Front Desk Wireless Call-Log Capture Defect	Number of non-captured Wireless requests/services via front desk	Discrepancies between manual counting on front desk Wireless related requests / services against HMS.
3.	Front Desk AV Call-Log Capture Defect	Number of non-captured AV requests/services via front desk	Discrepancies between manual counting on front desk AV related request/issue against HMS.
4.	Front Desk Moodle / Portal Call-Log Capture Defect	Number of non-captured Moodle requests/services via front desk	Discrepancies between manual counting on front desk Moodle / Portal related requests / services against HMS.
5.	Front Desk Student Satisfaction Level	Satisfaction Level of front desk services	Accumulative Front Desk satisfaction level against Incident Satisfaction Level

Source: Case study analysis compilation

A timesheet (or time sheet) is a time costing method for recording the amount of a worker's time spent on each job. Times costing has become a necessarily important implementation for most organization. It acts as a written proof for the amount of time the employees have worked by simply keeping track of the work done by your employees. In the context of project management, timesheets can also be used to build a body of knowledge about how much effort tasks take to develop. Most importantly, timesheet has the ability to track resource costs and project expenses to allow for better future budgeting. Accumulate times costing for projects tasks representative work on a particular or distinct project.

Figure 38 SIPOC Diagram for IS Helpdesk Support (UNMC)

Supplier	Input	Process	Output	Customer	Requirements
EMS DB	Student ID	Received Request/Problem via Email, Walk-in & Telephone Calls	IT Services	Students	Registered Students
Hardware vendor	University Rules and Policy	Log into Helpdesk System with Call-Reference Number	IT Hardware	Operational Departmental Head / Manager	University Staff
Software vendor	Respective Course Information	Attend to Request	IT Software	Professors	Valid Username
Internet Service Provider	Staff ID	Update Call-Reference Status into Helpdesk System	IT Training	Assistant Professors	Resolved Request/Problems within specified time frame
Telecommunication Companies	Hardware and Software	Follow-up with email correspondence		Lecturers	
Network Infrastructure Supplier	Network	Close Call-Reference if Request/Issue Resolved		Researchers	
Printer	Internet Connection			Guests	
	IT knowledge-based resources			Management Personnel	

Source: Case study analysis compilation

The preliminary investigation revealed that the IS Support is experiencing an inefficient time-cost budgeting on front desk as a majority of the attended front desk requests were not captured into HMS. Due to the lack of effort in capturing attended IT requests/services into HMs, reports generated from the HMS do not reveal the actual performance of the helpdesk team, which further complicates resource management and utilization in better responding to any ad-hoc requests which required immediate attention.

6.3 Measure Phase

6.3.1 Introduction To Data Collection

Two methods were employed in the data collection: (1) On-the-job observation, and (2) Brainstorming. The aim of the on the-job observation is to capture number of IT requests/services during the observed period for a week-long duration. The mode of services inclusive of walk-in and phone calls. Brainstorming is a group or individual creativity technique by which efforts are made to find a conclusion for a specific problem by gathering a list of ideas spontaneously contributed by the customer service team.

The second phase involved the **analysis of survey feedback** and recommendations for the round of April 2010, December 2010, April 2011, December 2011 as well as December 2012. The omission of survey data for April 2012 was due to staff unavailability during the survey. The survey feedback and recommendation were in open-ended question where answers had been pre-coded into different categories.

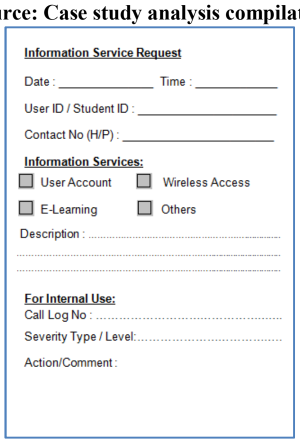
6.3.2 Findings: On-The-Job-Observation

The main objective for job observation is to capture all requests/services via front desk walk-in and front-desk phone-call. This on-the-job observation aims to capture and measure the volume of front desk activities during the first week of registration; which later mapped and tracked against the Helpdesk Management System (HMS) to ensure front desk activities are captured into the system. Upon understanding and expecting huge crowd at the front desk during the first week of registration for September main intake, a paper note named Information Service Request Form (Figure 39) was suggested in capturing as many front desk requests and services as possible. The reason of introducing a new form is due to students normally coming in batches at different times where there are only two front desk officers assigned attending and providing services to students' requests. It is crucial and important to solve students' request/services as soon as possible to ensure front desks are always clear and available for the next batch of student crowds; at the same time being able to capture all attended services/requests performed by front desk officers and logged into HMS.

With past experience, the most commonly required assistance and/or request and/or services captured during registration week is related to User Account, AV, Wireless Access and E-Learning. Hence, only these three services are listed in the forms for ease of capturing by selecting pre-coded IS Service options.

Prior to the start of on-the-job-observation, a briefing was conducted to front desk officers about existence of the IT Request Form (Figure 39) which could assist them in capturing and managing services/requests they have attended. During the on the-job-observation, it was observed that it is crucial and important to solve customers' request/services as soon as possible to ensure front desks are always clear and available for the next batch of customer crowds; at the same time being able to capture all attended services/requests performed by front desk officers and logged into HMS. Hence, all walk-in and phone calls services/requests are capture via the IT Request Form to ease recording and mapping of attended requests/services into HMS. There are no suggestions and improvements being discussed and/or implemented in the Measure phase. The front desk officers are asked to perform their tasks as per their norms. In some cases, time/duration taken to attend to a single request/service is recorded. Timing is done on a random basis as there would be overlapping of requests/services at different time intervals and it is greatly dependent on the availability of the front desk officers.

Source: Case study analysis compilation



Information Service Request

Date : ____________ Time : ___________

User ID / Student ID : __________________

Contact No (H/P) : __________________

Information Services:

☐ User Account ☐ Wireless Access

☐ E-Learning ☐ Others

Description : ....

For Internal Use:

Call Log No : ....

Severity Type / Level: ....

Action/Comment :

Figure 39 Information Service Request Form [249]

The following summarized the observations captured during the registration week:

- New students reported the temporary username and password distributed in the registration-pack is not valid
- New students are not well-informed on assigned Student-ID which in-need for username retrieval and account activation.
- Non IT savvy new students find difficulties in understanding the instruction for username retrieval and account activation.
- Majority of returning students seeks help re-setting password after long semester break.
- Wireless connection requires front desk officers' attention and assistance. Time taken performing single wireless request is quite significant depending on type of issues.

Upon completion of the on-the-job observation, all attended front desk IS Requests/Services (i.e. walk-in and phone call) were recorded and tabulated. Besides, call-logs in the Helpdesk Management System from 18th to 25th September were tracked, mapped and compared against front desk IS Support activities. During the on-the-job observation, all attended front desk IS Services were recorded manually using the IS Service Request Form. At the end of the observation day, all the attended and recorded front desk IT Services in respective service categories are summarized in Table 68. As discussed earlier, the routine of IS Support via email account of ITServiceDesk@nottingham.edu.my is captured into HMS and is summarized into Table 69.

The next step is to determine if these attended front desk IT Requests/Services are logged into HMS. This is when the IT Service Request form are used to cross-check against each call-log-ID in HMS to determine if respective front desk officer completes helpdesk cycle by updating the data into HMS. This task can be done with high accuracy as compulsory fields in the HMS were captured in the IT Service Request form. The outcome of mapping activity of Table 68 against Table 69 was tabulated in Table 70. The objective of mapping Total Front Desk call-logs and total HMS call-logs is necessary to avoid data bias.

In general (refer to Table 70), the data collection shows a *significantly high tendency* of front desk officers *not* recording attended Wireless Access (98%) request/service into HMS, followed by User Account (87%), E-Learning (82%) and A/V (0%).

Table 68 Summary of Manual Tracking (Tel/Walk-in)

Date	User Account	AV	WiFi	Moodle/Portal	Others	Total
18th Sept 2012, Tuesday	24	1	3	4	0	32
19th Sept 2012, Wednesday	34	1	10	10	0	55
20th Sept 2012, Thursday	10	3	2	12	4	29
21st Sept 2012, Friday	9	0	3	8	2	22
24th Sept 2012, Monday	33	4	14	26	1	78
25th Sept 2012, Tuesday	13	1	14	35	1	64
TOTAL	**123**	**10**	**46**	**95**	**8**	**282**

Source: Case study analysis compilation

Table 69 Summary of Call-Log from Helpdesk Management System (HMS)

Date	User Account		AV		WiFi		Moodle / Portal		Others	
	Tel / Walk-in	Email	Tel / Walk-in	Email	Tel / Walk-in	Email	Tel / Walk-in	Email	Tel / Walk-in	Email
18th Sept 2012, Tuesday	0	0	1	1	0	0	0	0	4	5
19th Sept 2012, Wednesday	0	3	1	0	0	0	0	0	15	6
20th Sept 2012, Thursday	4	0	3	1	0	0	5	1	14	8
21st Sept 2012, Friday	2	1	0	2	0	0	2	2	3	7
24th Sept 2012, Monday	8	2	4	2	0	0	8	19	36	7
25th Sept 2012, Tuesday	2	3	1	3	1	0	2	34	7	7
TOTAL	**16**	**9**	**10**	**9**	**1**	**0**	**17**	**56**	**79**	**40**

Source: Case study analysis compilation

Table 70 On-The-Job-Observation Outcomes [249]

IS Service Type	User Account (Tel/Walk-in)			AV (Tel/Walk-in)			Wireless Access (Tel/Walk-in)			E-Learning (Tel/Walk-in)		
Day	Front Desk (F/D)	Map into HMS	Non-recorded (%)	Front Desk (F/D)	Map into HMS	Non-recorded (%)	Front Desk (F/D)	Map into HMS	Non-recorded (%)	Front Desk (F/D)	Map into HMS	Non-recorded (%)
18th Sept 2012	24	0	100%	1	1	0%	3	0	100%	4	0	100%
19th Sept 2012	34	0	100%	1	1	0%	10	0	100%	10	0	100%
20th Sept 2012	10	4	60%	3	3	0%	2	0	100%	12	5	0%
21st Sept 2012	9	2	77%	0	0	0%	3	0	100%	8	2	58%
24th Sept 2012	33	8	76%	4	4	0%	14	0	100%	26	8	69%
25th Sept 2012	13	2	85%	1	1	0%	14	1	93%	35	2	94%
Total	**123**	**16**	**87%**	**10**	**10**	**0%**	**46**	**1**	**98%**	**95**	**17**	**82%**

Source: Case study analysis compilation

6.3.2.1 User Account Services

6.3.2.1.1 Findings

Source: Case study analysis compilation

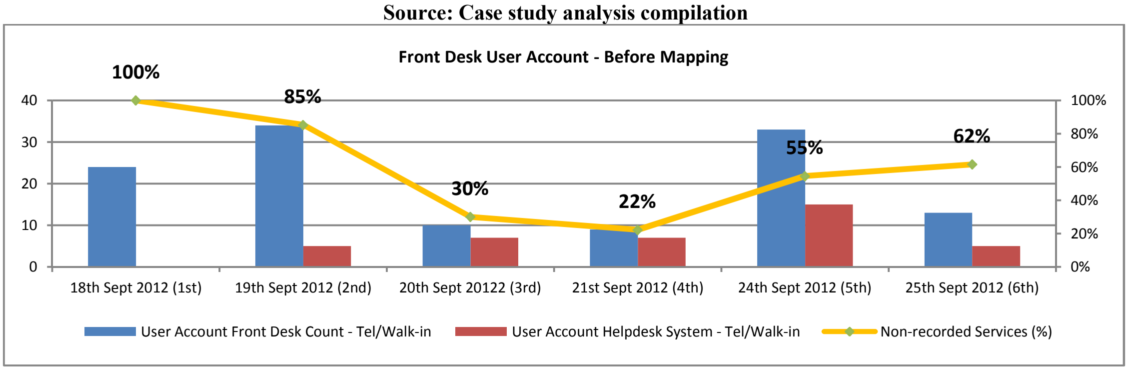


Figure 40 User Account – Before Mapping (UNMC)

Figure 40 tabulated the comparison of User Account services between front desk and HMS (only walk-in, excluding call-logs captured via email) before taking consideration into call-log(s) captured from the front desk and logged into HRM. It showed that majority of students preferred seeking help from front desk on User Account related activities. However, there are a small group of students will send in request via email to general helpdesk account (IT Service Desk: ITServiceDesk@nottingham.edu.my) where helpdesk officers will perform verification before attending the request.

Source: Case study analysis compilation

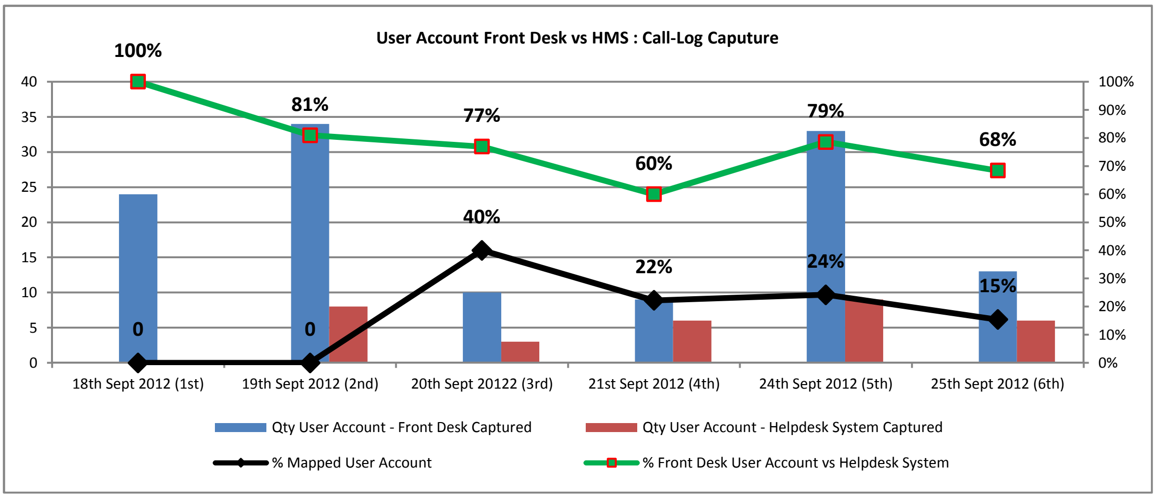


Figure 41 User Account – After Mapping (UNMC)

The findings from Figure 41 taken the consideration into mapping of call-log captured at front desk which was updated into HMS. Those call-logs captured via front desk which were updated into HRM were excluded from the HMS to avoid redundancy count. Besides, total counts from HMS are inclusive of all call-logs captured into HMS (both via walk-in and email).

In general, the line chart in Figure 40 shows a high percentage of attended Front Desk User-Account related services are not being captured formally into HMS. An average of 59% of front desk attended user account related activities are not captured into HMS. From the view point of total attended User-Account services via Front Desk versus HMS, it was noticed an average of 77% of daily total User-Account related activities are captured via Front Desk (line chart in Figure 41). This statement is supported by the bar chart statistics (Figure 41) which compares total quantity of User-Account services between Front Desk and HMS where the blue bars are much taller than the red bars. *In short, User-Account related activities are generally much higher over Front Desk*. This revealed that HMS does not reflect the real helpdesk activity volume where a major portion of the attended services/requests were left unrecorded and not updated into HMS. In the effort of using HMS as a central pool of database capturing day-to-day IS Support related activities for the IT Department, there is an urgent need to review current work culture and work practices ensuring attended services/requests are recorded into HMS. It is important to raise awareness among the helpdesk officers about the need of completing the front desk cycle by updating the attended services/requests into HMS.

Although the related activities from Front Desk User Account are mainly to reset passwords, it has the highest cases captured (77%) compared to enquiry through Email, as observed from the total cases of User Account related services during the six-days observation period. None of the attended front desk User Account requests/services were recorded into HMS on the first and second day of the observation, the result for the subsequent days (Day-3, Day-4, Day-5 and Day-6) were disappointing too (i.e. 60%, 77%, 76% and 85% respectively). In view of the statistical findings which showed a high percentage of User-Account Services being neglected in Front Desk operation, a detailed analysis was streamlined to capture time taken to perform a “single” User Account request/service.

Table 71 Summary of Time Taken Attending Single User Account – Reset Password (UNMC)

Date	Log Status	Time Taken (seconds)
20th Sept 2012	No	17.33
20th Sept 2012	No	19.51
20th Sept 2012	No	18.13
20th Sept 2012	No	16.11
20th Sept 2012	No	17.38
20th Sept 2012	Yes	40.47
20th Sept 2012	Yes	38.12

Date	Log Status	Time Taken (seconds)
20th Sept 2012	Yes	41.38
20th Sept 2012	Yes	42.17
21th Sept 2012	No	18.11
21th Sept 2012	No	17.52
21th Sept 2012	Yes	43.02
21th Sept 2012	No	17.03
21th Sept 2012	Yes	45.03
21th Sept 2012	No	19.05
21th Sept 2012	No	20.23

Source: Case study analysis compilation

Source: Case study analysis compilation

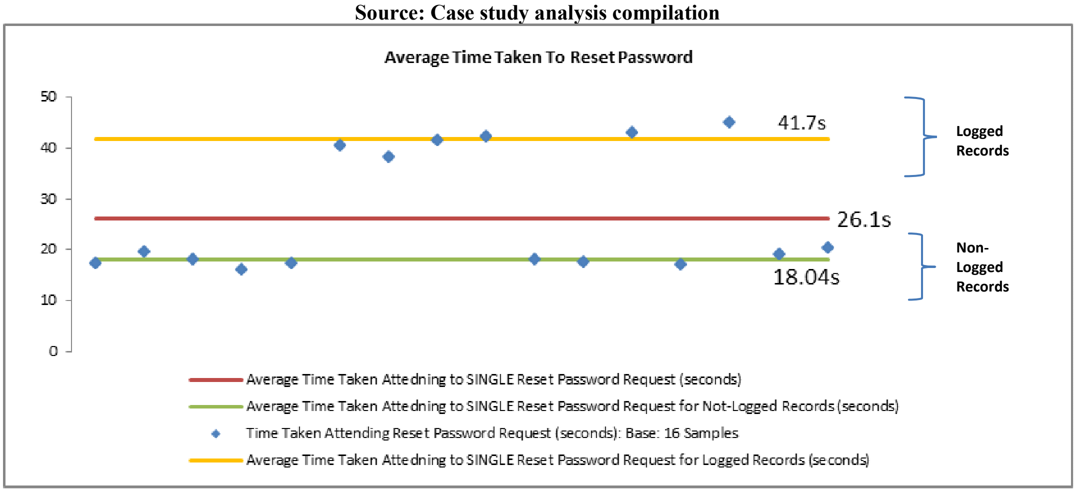


Figure 42 Time Taken Attending Single User Account Service (UNMC)

Data from Table 71 was tabulated in a scatter diagram in Figure 42. It was observed a pattern of upper and lower domain dominant in the scatter diagram. After detailing these two groups of data, the logged User-Account services are scattered at the upper diagram whereas the lower diagram tabulated the non-logged User-Account services. Sixteen random samples (Table 71) were selected and results showed that the average time taken for cases that are **NOT recorded into HMS were 18.04 seconds** (with 10 samples) while **cases recorded into HMS took 41.70 seconds** (with 10 samples).

6.3.2.1.2 Conclusions

It was obvious and proven that most Front Desk User-Account related activities were left unrecorded into HMS; i.e. average of 83% were left unrecorded and only an average of 17% of attended Front Desk User-Account related activities are reflected into HMS. Although it is argumentative that time taken to update a Front Desk User-Account service is 41.7s which is significant comparing to 18.04s (non-recorded), the total count of Front Desk User-Account related activities constitute 77% of the total count for daily User-Account related activities. Even though the helpdesk officers have delivered and fulfilled students/staff requests/services, it is necessary and important to record and log all attended requests/services into HMS reflecting the actual activities volume for IS Support.

6.3.2.1.3 Recommendations

Since most information pertaining to attended Front Desk User-Account related activities are captured though the IS Service Request form (Figure 39), Front Desk Officers should update all attended requests/services into HMS as it would only takes less than a minute to reflect it in HMS. Furthermore, in the peak of 34 cases (19th September 2012) within a day, it only takes 708.9 seconds or 11.82 minutes for each Front Desk Officers (i.e. (34 x 41.7s)/2; currently there are two front desk officers). Even though the total time (calculated) required to log-in 124 attended Front Desk User Account requests/services into HMS is 1.26 hours, it is only about 3% of total helpdesk time for the six-day duration (based on an 8-hour working day).

6.3.2.2 Wireless Access Services

6.3.2.2.1 Findings

Source: Case study analysis compilation

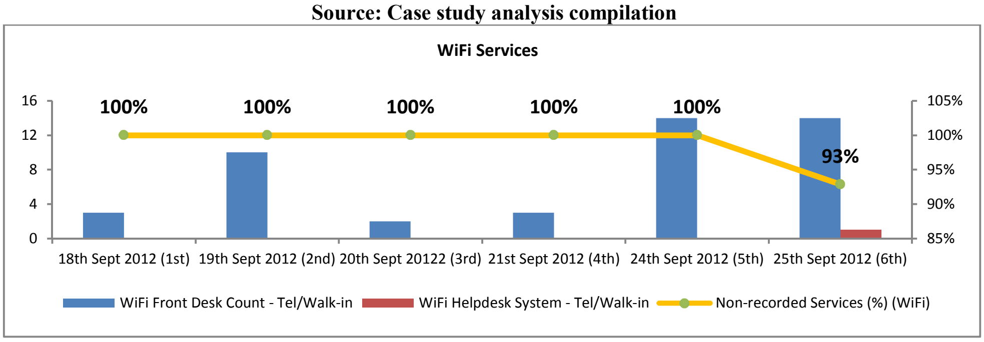


Figure 43 Wireless Services – Before Mapping (UNMC)

Source: Case study analysis compilation

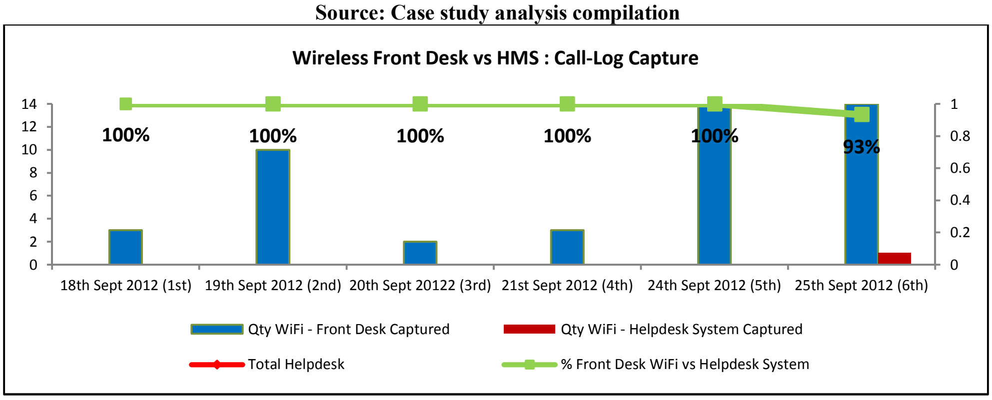


Figure 44 Wireless Services – After Mapping (UNMC)

Figure 43 and Figure 44 tabulates the comparison of Wireless Service between front desk and HMS (only walk-in, excluding call-logs captured via email) before taking consideration into call-log(s) captured from front desk and logged into HMS. The preference of personal attention for Wireless Services is undeniable with 100% being captured via the Front Desk counter (except for 25th September 2012 with 93%). The balance of 7% recorded on 25th is due to student requesting hardcopy guideline on Wireless setup. In short, 100% or all of the Wireless Service related activities are captured through Front Desk counter. This is supported with the red line chart showing zero percentage of front desk Wireless Services related activities are mapped into HMS.

Although the numbers of attended Wireless Services are much lesser compared to User-Account Services, a random of 38 samples were timed on total time taken attending single Wireless request/services.

Table 72 Summary of Time Taken Attending WiFi Request (UNMC)

Date	Time Taken (minutes)	Date	Time Taken (minutes)	Date	Time Taken (minutes)
18th Sept 2012	17	19th Sept 2012	24	24th Sept 2012	32
18th Sept 2012	27	20th Sept 2012	9	24th Sept 2012	24
18th Sept 2012	16	20th Sept 2012	32	24th Sept 2012	30
19th Sept 2012	21	21st Sept 2012	22	25th Sept 2012	4
19th Sept 2012	18	21st Sept 2012	30	25th Sept 2012	21
19th Sept 2012	10	21st Sept 2012	8	25th Sept 2012	23
19th Sept 2012	35	24th Sept 2012	31	25th Sept 2012	17
19th Sept 2012	21	24th Sept 2012	25	25th Sept 2012	15
19th Sept 2012	21	24th Sept 2012	35	25th Sept 2012	26
19th Sept 2012	26	24th Sept 2012	23	25th Sept 2012	5
19th Sept 2012	39	24th Sept 2012	10	25th Sept 2012	48
19th Sept 2012	17	24th Sept 2012	50	25th Sept 2012	45

Source: Case study analysis compilation

Upon in-depth analysis of data set from Table 72 and scatter pattern from Figure 45, it was observed that data are strongly coupled at middle and lower domain in the scatter diagram. The middle sections are the collective of attended Laptops Wireless requests whereas the lower section was dominated by Smart Phone Wireless request. The results showed an average time taken to resolve wireless networking related issue on laptop is 25.81 minutes (based on 32 samples) and 8 minutes for smart phone (6 samples). Although total Wireless Access cases (46 cases) are much fewer than User Account (123 cases), the observed time taken is significantly higher.

Based on the computed average time taken in Figure 45, a combination of bar chart and line chart of Total Time Spent on Wi-Fi Requests/Services at Front Desk during 18th – 25th September 2012 for both Laptop and Smart Phone are tabulated in Figure 46. Total time spent on attending Wireless Services on Day-2, Day-5 and Day-6 are 4.22 hours, 4.64 hours and 4.64 hours respectively; this implies that more than 50% of total help desk time (based on an 8-hour working day) were spent on Wireless related activities and in deed consumed a significant level of resources in the helpdesk daily routine.

Source: Case study analysis compilation

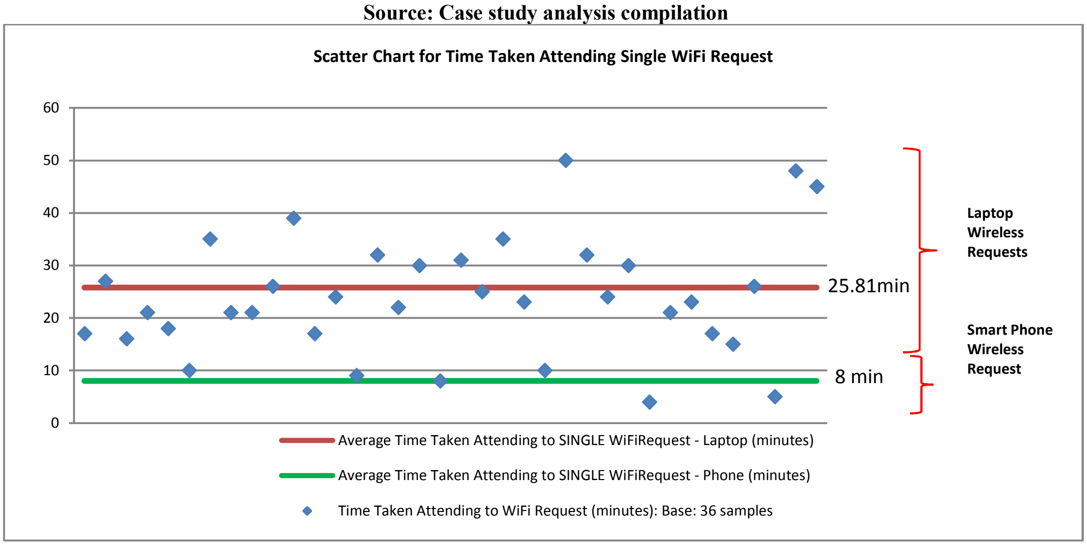


Figure 45 Time Taken Attending Single User Account Service (UNMC)

Source: Case study analysis compilation

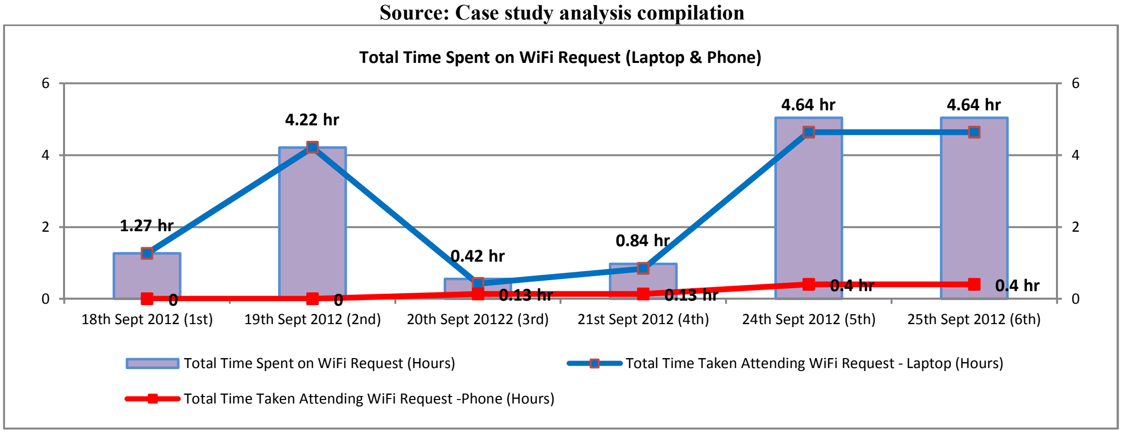


Figure 46 Total Time Spent on Wire Requests/Services (Laptop & Phone) (UNMC)

6.3.2.2.2 Conclusions

Almost all (98%) attended Wireless Access cases via front desk were not captured into HMS. It is common that customers desired on-the-spot resolution to minimize disruption to their work routine and hence prefer to head directly to the front desk for Wireless related activities as specialized knowledge and expertise in networking is needed.

It is an unexpected surprise to observe that more than 50% of front desk time was spent on attending Wireless Services. IS Support provides a vast variety of IS Services and it is important to ensure all requests/services via Front Desk are well attended and serviced. Unexpected time taken into Wireless Services has left not much time for other services. Besides, IT Department is expecting more Wireless Services in semesters to come as “IT is leading the way towards education”. Though the Wireless count may seem insignificant, but total time taken attending single wireless request/service is significant.

6.3.2.2.3 Recommendations

The Front Desk Officers and the IT Team should investigate the root-cause of Wireless services taking an average of 25.81 minutes attending single request/service. At the same time, the IT Department should explore other possibilities of request/service platform for Wireless Services beside Front Desk. This is to ensure Front Desk officers can allocate time to attend other IS Services.

6.3.2.3 E-Learning Services

6.3.2.3.1 Findings

E-Learning Services provides students easy accessibility to relevant information for learning purposes. It is a virtual learning and sharing of information, news and documents between staff and students cross the university. Moodle is a platform/workspace where students are allowed to self-select and self-enroll to modules without having to appear physically over the registration counter. Since Moodle is an UK based system, the main control and system management of database resides at the UK site and it is an official and compulsory workspace to be implemented cross the Malaysia, Ningbo and UK campuses. Since Moodle is an independent workspace, only staff undergoes Moodle training and with necessary Moodle knowledge are eligible in handling Moodle Services. Therefore, all Moodle related requests/services are directed to trained officers only.

Source: Case study analysis compilation

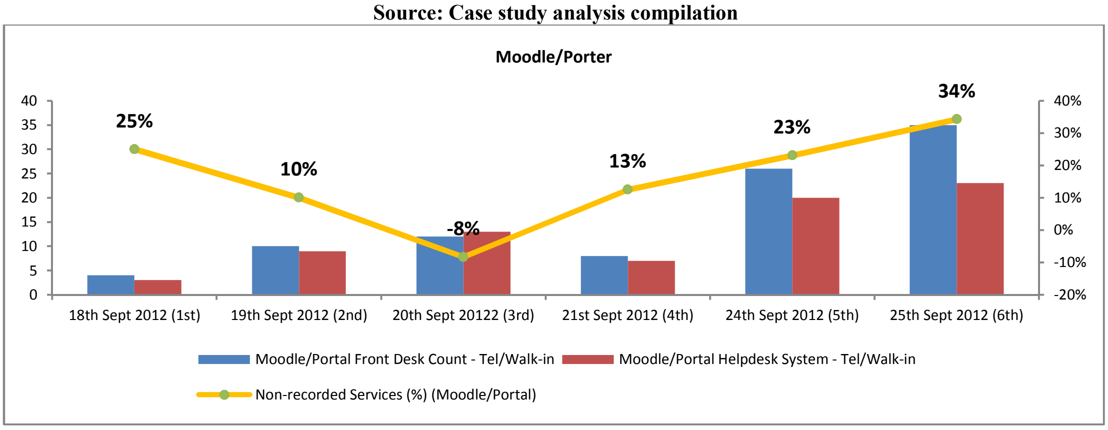


Figure 47 Moodle/Portal Services (UNMC)

6.3.2.3.2 Conclusions

Figure 47 shows that comparisons of quantity Moodle/Portal Services captured via Front Desk against HMS. Although E-Leaning only contributes 35% of total attended front desk requests/services, it is important to cultivate a positive work culture of capturing attended requests/services into HMS. The existence of unrecorded Front Desk Moodle/Portal services into HMS is due to new username has yet to be uploaded to Moodle by the UK site during the registration week. As a result, these “Front Desk recorded Moodle/Portal Services” did not reflect into HMS. However, it was observed from the past experience that once the UK site completes the new username uploading, the count requesting for Moodle/Portal Services reduces tremendously.

6.3.2.3.3 Recommendations

The research team would suggest the Front Desk Officers perform the first level screening for Moodle/Portal Services. If the issue is related to new username creation by the UK site, Front Desk Officers can inform the students/staff without having to direct them to Moodle Officers. In the event of a request/service is required, student should fill in the Information Service Request Form before heading to Moodle/Portal Officers.

6.3.2.4 AV Services

6.3.2.4.1 Findings

The acronym/abbreviation AV means **A**udio/**V**ideo. AV refers to equipment and applications that deal with sound and sight. The AV world includes microphones, tape recorders, audio mixers, still and video cameras, film projectors, slide projectors, VCRs, CD and DVD players/recorders, amplifiers and speakers. The AV Services in UNMC is generally related to equipment in the lecture hall. In most cases, telephone call(s) on AV Services related is expected just 5-10 minutes before the start of a lecture. It is the duty of the Front Desk Officers to capture the call and assign respective station officer assisting and solving the AV matters. In general, the nature of A/V request/service is on an ad-hoc basis and requires immediate attention and resolution within 0.5 hours. In the past, the information of the AV cases is always attended without trailed records.

Source: Case study analysis compilation

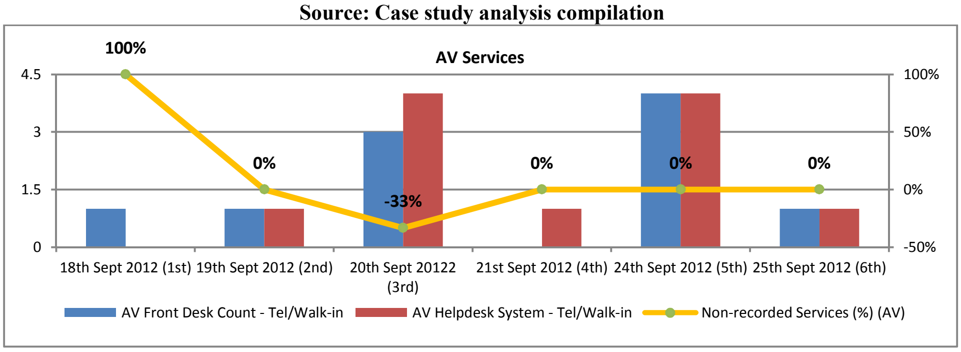


Figure 48 AV Services (UNMC)

6.3.2.4.2 Conclusions

During the on-the-job observation, all AV cases are captured over the first level Front Desk Officer via Information Service Request Form. The count of Front Desk AV Services and the corresponding comparison of Front Desk versus HMS AV Services is outline in Figure 48. Majority of the attended request/service for Front Desk A/V were recorded into HMS as there is a preference to resolve the ticket as soon as possible to avoid any delays of training, orientations, launchings, campaigns etc. Although there aren't many cases captured via the front desk, A/V request/services demonstrated a good helpdesk working culture. This proves that the Information Service Request Form is indeed an important medium in handling ad-hoc front desk requests/services where details of attended requests/services can be captured into HMS to reflect actual daily operational statistics.

6.3.2.4.3 Recommendations

The Information Service Request Form should be formally adopted as a formal departmental form for IT Department. This form especially comes handy for ad-hoc IS Services which requires immediate attention where details can be captured for later data entry into HMS for recording purposes.

6.3.2.5 General IS Support Services

6.3.2.5.1 Findings

In view of data gathering for respective IS Services, Figure 49 outlined the comparison of Non-recorded Front Desk Services into HMS for User-Account, AV, Wireless and Moodle/Portal. It was observed that AV Services is amongst the most well-updated front desk services into HMS with recording of almost 100% front desk AV related requests/services being captured into HMS. Since the statistics of Moodle/Portal Services was biased, it will be excluded for discussion. Although User-Account Services is the next in-line after Moodle/Portal Services, the chances of Front Desk User-Account Services NOT captured into HMS is high as quantity count is significant comparative to total HMS counts. Wireless Services is the most disappointing where 100% of the Front Desk Wireless Services are not captured into HMS and yet time attending to single Wireless Service is significant to Front Desk resources.

Source: Case study analysis compilation

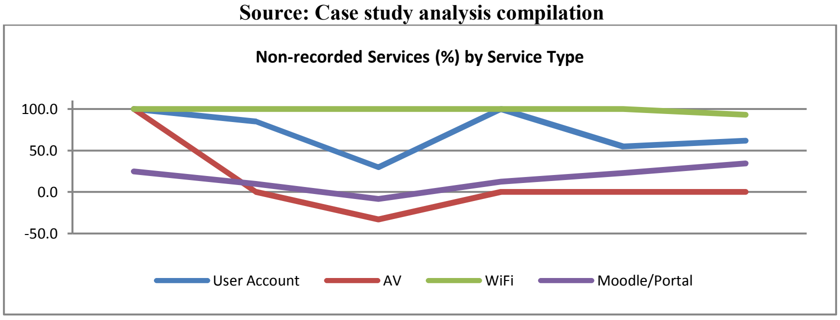


Figure 49 Non-recorded Services (%) by Service Type (UNMC)

As discussed earlier in the Define phase, the research team is justifying if IS Support is facing an untruth budgeting from the front desk time costing. In view of Figure 50, it was observed that more than half (i.e. 52%) of the total IS Services is contributed through Front Desk channel with some days dominant the total IS Support counts and vice versa.

Source: Case study analysis compilation

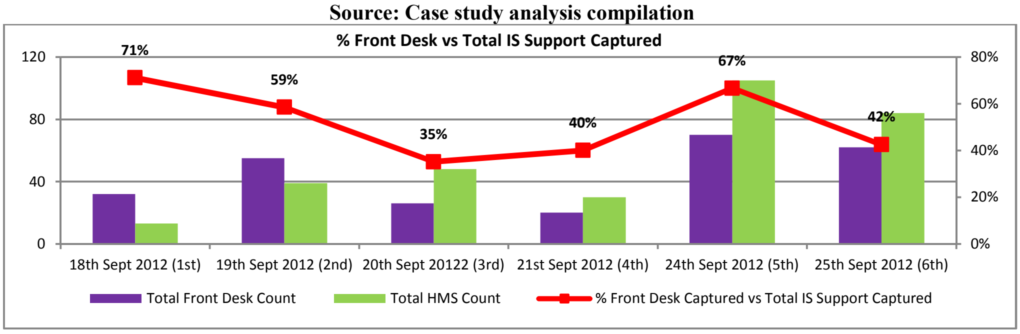


Figure 50 Front Desk versus Total IS Support Captured (UNMC)

Source: Case study analysis compilation

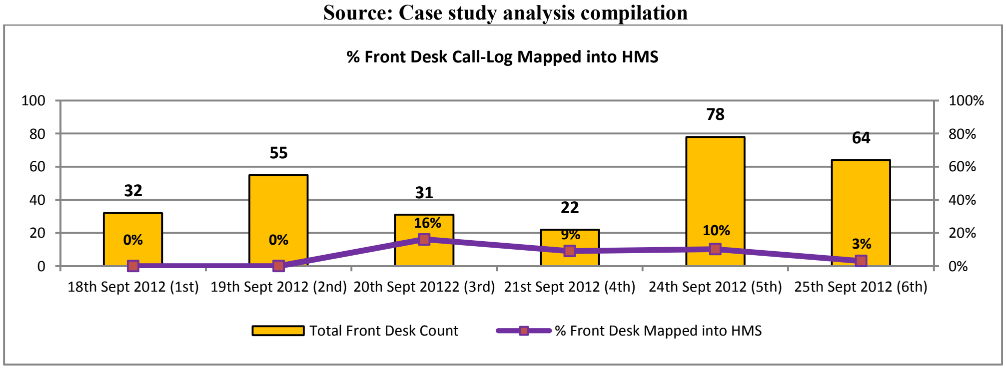


Figure 51 Front Desk Call-Log Mapped into HMS (UNMC)

6.3.2.5.2 Conclusions

The computed average of 52% contribution of Front Desk call-logs captured through front desk has proven that Front Desk is an important source of entries into HMS which cannot be neglected. The line chart tabulated in Figure 51 further supported this statement where there is only an average of 6% of the front desk attended requests/services are recorded into HMS to reflect actual IS Support activities, leaving 94% are left unrecorded.

6.3.2.5.3 Recommendations

Regardless of attended IS Support activities captured through Front Desk or Email, it is necessary to reinforce the importance of recording and updating attended IS Services into HMS. If the point of work condition or scenario is not permitting or allowing officers instance updating or recording any attended IS Support requests/services into HMS, it is necessary to establish an operational guideline and make awareness among the IS Support officers in completing front desk cycle flow into HMS. Attended IS Support Services cannot be left unrecorded as this complicates time cost budgeting justification for acquiring IS resources as well as resource re-allocation.

6.3.3 Findings: Survey Feedback

6.3.3.1 Front Desk Support Services

Despite gathering and measuring quantitative data via front desk, the research team is seeking qualitative measurement via descriptive feedback gathered from student surveys. A pool of open-ended feedback and recommendations from bi-yearly survey on IT Services were analyzed and tabulated. Five rounds of data (i.e. April 2010, December 2010, April 2011, December 2011 as well as December 2012) were collected. These survey feedback and recommendation were captured as open-ended question and answers had been pre-coded into categories of Wireless, Email Quota, Hardisk Quota, Scanner, Printing and Lab PC. The category of Lab PC is further drilled into the sub-category of Lab PC Cleanliness, Lab PC Availability and Lab PC Performance. Table 73 outlined the tabulation of open-ended data collection with pre-coded answer into respective categories.

Table 73 Summary of Open-Ended Feedback – Result of Student Survey (UNMC)

Date	April 2010	December 2010	April 2011	December 2011
Wireless	29	61	39	32
Email Quota	8	8	6	2
Hard disk Quota	7	7	3	5
Scanner	2	2	1	1
Printing	12	52	26	52
Lab PC	**60**	**109**	**91**	**419**
Lab PC Cleanliness	6	12	9	34
Lab PC Availability	54	97	74	241
Lab PC Performance	0	0	8	144

Source: Case study analysis compilation

A bar chart comparison of student survey feedback for year 2010 and 2011 tabulated in Figure 52 showed an obvious increase of complaints (for Lab PC and Printing at year 2011). Both the Lap PC and printing feedback were further break down in Figure 53 into respective survey period to ease of root-cause diagnosis.

Source: Case study analysis compilation

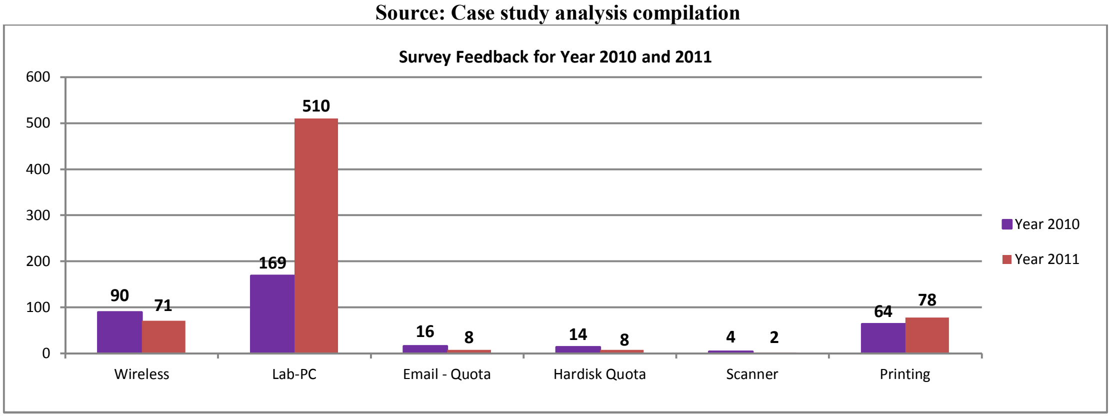


Figure 52 Student Survey Feedback for Year 2010 and 2011 (UNMC)

Source: Case study analysis compilation

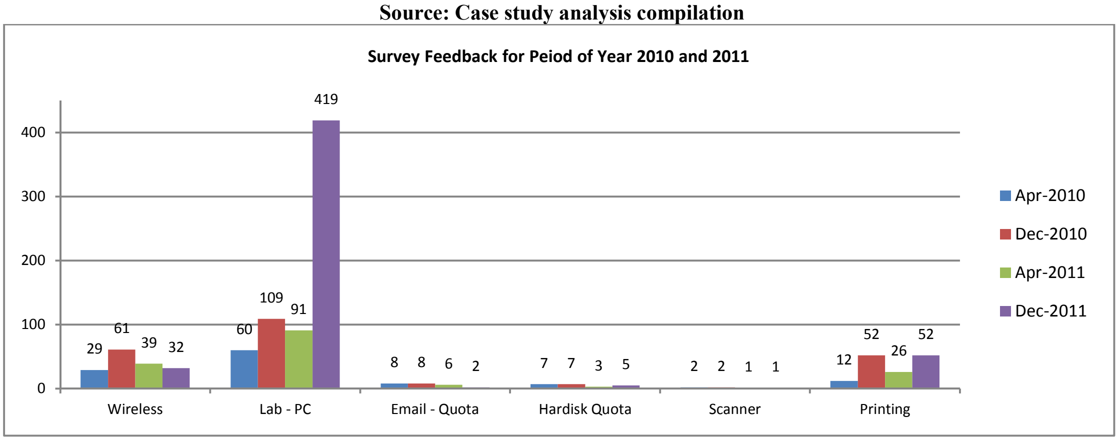


Figure 53 Survey Feedback for Period of Year 2010 and 2011 (UNMC)

In Figure 53, it was observed an exponential increase complaint for printing services for the December 2011 survey due to increase in printing cost in the September semester. Besides, many complaints about printers in the PC room are not connected to PC which made printing difficult, waste of time and waste of paper resources.

Source: Case study analysis compilation

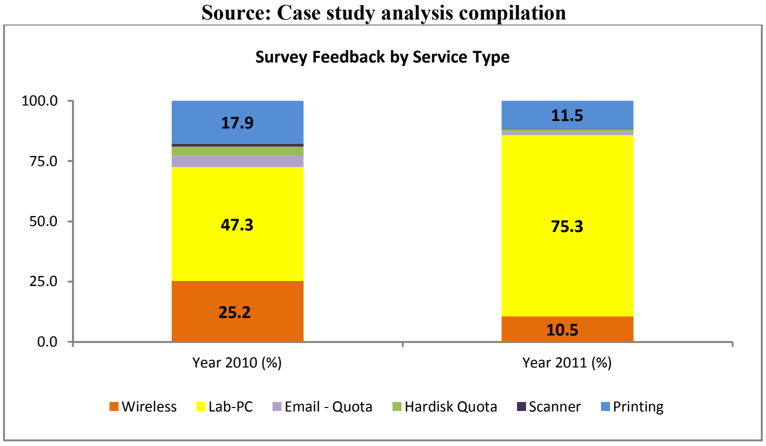


Figure 54 Survey Feedback by Service Type (UNMC)

The overall feedback from student survey complaints are tabulated into stacked bar (Figure 54) to ease of setting priorities. It was obvious that Lab PC is indeed required immediate action with 169 cases reported in year 2010; which is about half (47%) of total complaint for year 2010 and demonstrated an unhealthy sign of 75% contribution to year 2011 survey (Figure 56). This shows that Lab PC is the “EVENT” that IS department should further its investigation.

In general, complaints of Lab PC can be sub-categorized into PC Cleanliness, PC Availability and PC Performance. The PC Cleanliness complaints touched on hygiene factors for mouse, key board, PC working table, condition of the lab etc. The main factor contributing to this cleanliness factors is about irresponsible students ignoring Lab’s rules and regulation bringing food and drinks into the lab. The issue of PC availability is about classes are conducted in the lab; big labs were blocked (30-40 PCs) attending a small class group with less than ten students. Besides, there are 40%-50% reported cases where PCs in the lab are left unrepaired for more than three weeks. This had contributed the raised of disappointment for lab users. However, there is no sign of complaint for PC performance in year 2010 (Figure 55).

However in year 2011, complaints on PC performance has increased to 22% where complaints for PC cleanliness and PC availabilities had increased to 6% and 47% respectively. The main reason for this drastic increase of PC complaints is due to change of IT strategy to pro-long salvage PC from 3-Years to 4-Years. PCs in the lab were not upgraded when it reached its’ third year lifespan in year 2010, instead the IT Department decided to extend PCs salvage lifespan to another year, i.e. 2011. The decision of pro-long PC life has raises performance issues in year 2011.

Source: Case study analysis compilation

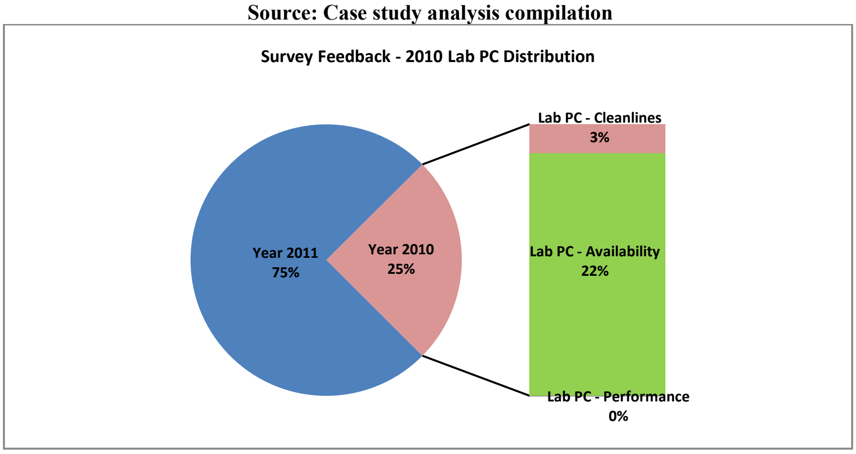


Figure 55 Year 2010 Lab PC Percentage Distribution (UNMC)

Source: Case study analysis compilation

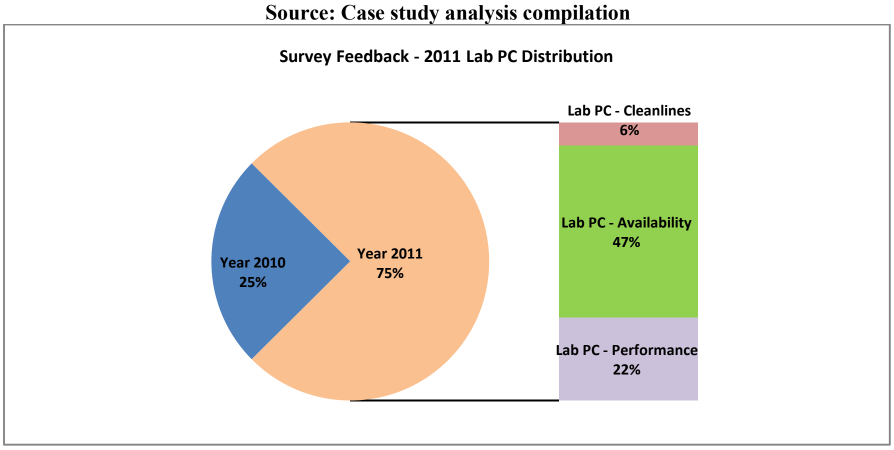


Figure 56 Year 2011 Lab PC Percentage Distribution (UNMC)

6.3.3.2 General IS Support Services

Both Figure 57 and Figure 58 tabulated strata pie charts for Year 2010 and Year 2011 respectively. These two figures clearly outlined the need of immediate attention to Lab PC services especially on the PC availability and PC performance. Failing to fulfill these two requests will result in student dissatisfaction towards IS Support Services. IS Support Services should aim for overall well-rounded IT Services, not limiting to front desk or emails supports only. It is necessary and important to raise the awareness of students' expectations towards university facilities.

Source: Case study analysis compilation

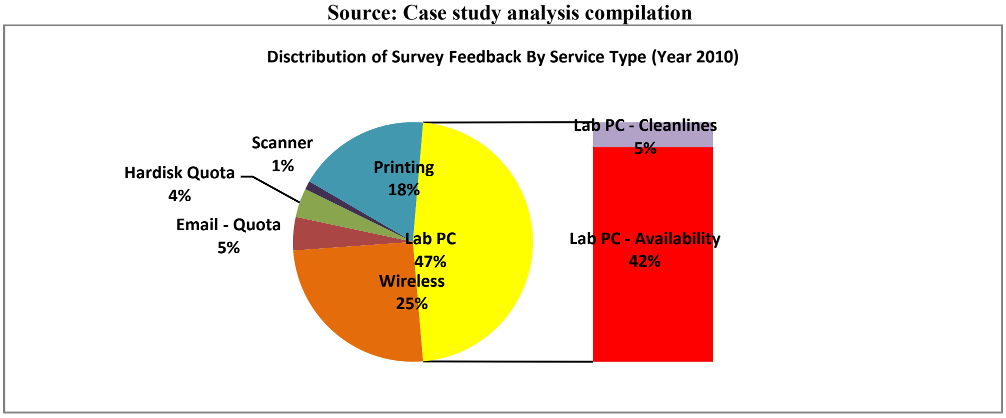


Figure 57 Distribution of Survey Feedback By Service Type (Year 2010)

Source: Case study analysis compilation

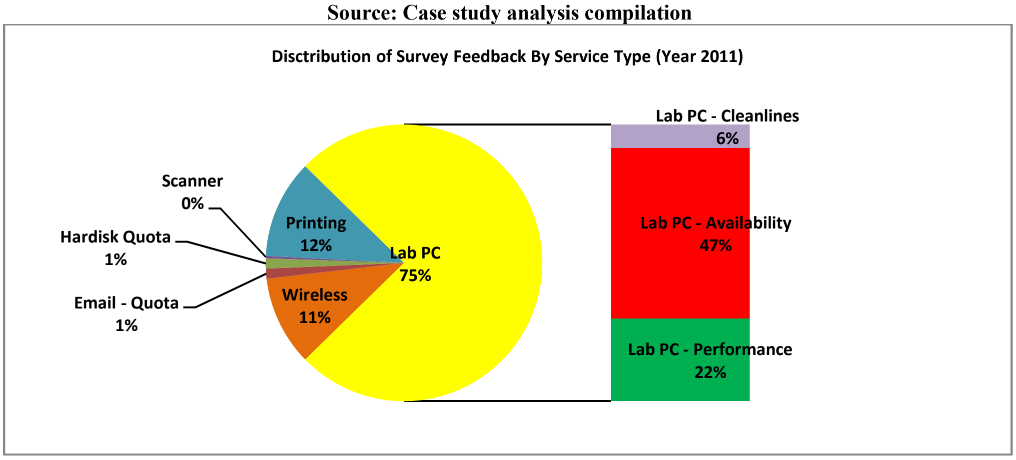


Figure 58 Distribution of Survey Feedback By Service Type (Year 2011)

6.3.4 Six Sigma Calculation

The defection of output measures serves to validate or define the problem and to begin the search for root causes, which is the objective of "Analyze" in the next phase. As such, Six Sigma calculations for Front Desk defections were computed and Front Desk defection can be further breakdown into User-Account Services defection, Wireless Services defection, AV Services defection and Moodle/Portal Services defection as shown in Table 74 and Table 75.

Table 74 Summary of Attended Front Desk Services Status into HMS (UNMC)

Date for Front Desk Service Type	Front Desk Count	Front Desk Services Mapped into HMS	Front Desk Services Unmapped into HMS	Email Count	Total Attended Services (Front Desk & Email)
User-Account Services					
18th Sept 2012 (1st)	24	0	24	0	24
19th Sept 2012 (2nd)	34	0	34	8	42
20th Sept 20122 (3rd)	10	4	6	3	13
21st Sept 2012 (4th)	9	2	7	6	15
24th Sept 2012 (5th)	33	8	25	9	42
25th Sept 2012 (6th)	13	2	11	6	19
TOTAL	**123**	**16**	**107**	**32**	**155**
Wireless Services					
18th Sept 2012 (1st)	3	0	3	0	3
19th Sept 2012 (2nd)	10	0	10	0	10
20th Sept 20122 (3rd)	2	0	2	0	2
21st Sept 2012 (4th)	3	0	3	0	3
24th Sept 2012 (5th)	14	0	14	0	14
25th Sept 2012 (6th)	14	1	13	0	15
TOTAL	**46**	**0**	**45**	**0**	**47**
AV Services					
18th Sept 2012 (1st)	1	1	0	1	1
19th Sept 2012 (2nd)	1	1	0	1	1
20th Sept 20122 (3rd)	3	3	0	3	3
21st Sept 2012 (4th)	0	0	0	0	0
24th Sept 2012 (5th)	4	4	0	4	4
25th Sept 2012 (6th)	1	1	0	1	1
TOTAL	**10**	**10**	**0**	**10**	**10**
Moodle/Portal Services					
18th Sept 2012 (1st)	4	0	4	3	7
19th Sept 2012 (2nd)	10	0	10	9	19
20th Sept 20122 (3rd)	12	5	7	14	26
21st Sept 2012 (4th)	8	2	6	9	17

Date for Front Desk Service Type	Front Desk Count	Front Desk Services Mapped into HMS	Front Desk Services Unmapped into HMS	Email Count	Total Attended Services (Front Desk & Email)
24th Sept 2012 (5th)	26	8	18	39	65
25th Sept 2012 (6th)	35	2	33	57	92
TOTAL	**95**	**17**	**78**	**131**	**226**
GRAND TOTAL	**282**	**44**	**238**	**174**	**438**
GRAND TOTAL + OTHERS	**290**	**0**	**246**	**293**	**557**

Note: A Total of eight (8) counts from Front Desk and one hundred nineteen (119) from Email fall into "Other Services".
Source: Case study analysis compilation

Table 75 Summary of Helpdesk Satisfaction Level for Year 2010 and 2011 (UNMC)

BottomTwo (Very Unsatisfied and Unsatisfied)	Apr-10	Dec-10	Apr-11	Dec-11
Friendliness	12	28	24	59
Communication Skills	13	30	20	54
Technical knowledge	13	27	22	58
Total Respondents	257	398	284	515

	Year 2010	Year 2011
Friendliness	40	83
Communication Skills	43	74
Technical knowledge	40	80
Total BottomTwo	**123**	**237**
Total Respondents	**655**	**799**

Source: Case study analysis compilation

In view of Six Sigma level from Table 76, Front Desk IT services of User Account, Wireless and E-Learning showed a low service level performance of 0.374s, -0.519s and 0.581s respectively. Therefore, front desk routine requires an effective and efficient way of strengthening and improving its operational activities of capturing attended front desk requests/services into HMS. Front Desk Wireless Access activities were computed with negative sigma value which indicates it is performing outside the case study company specification range; i.e. 45 out of 46 attended cases were left unrecorded into HMS.

In summary, capturing of Front Desk attended IS Support Services into HMS takes an average of 6% and leaving 94% unrecorded. Despite the helpdesk operational guideline is in place, IS Front Desk Support is still far short of capturing attended IS Services into pool of central HMS database. A high percentage (84%) of the attended front desk IT services was **not captured formally into HMS**. This implies that HMS does not reflect the real volume of helpdesk activity where majority of the attended services/requests were left unrecorded and not updated into HMS. In the effort of using HMS as a central database for capturing day-to-day IS Support related activities, there is an urgent need to review the current work culture and work practices to ensure all attended services/requests are recorded into HMS. It is important for helpdesk officers to understand the complete cycle of helpdesk activities (i.e. Attend Request/Service → Log Incident

→ Investigation, Analysis and Diagnosis → Resolution → Incident Closure) by updating the attended services/requests into HMS.

In general, although the survey result was tabulated with less than 25% of the respondents were unsatisfied with Helpdesk Support Services, it was observed an increase of dissatisfaction percentage from year 2010 to year 2011 from 19% to 30%. The team required to ensure the completion of front desk cycle for every attended service; and sees a need of dramatic improvement in the front desk operation routine to ensure IS Service efficiency and effectiveness as well as student and staff satisfaction.

6.4 Analysis Phase

6.4.1 Introduction

The front-desk job is a critical role in any organizations as well as in the university. Generally, the front desk officer is the first person customers (e.g. students, staff and guests) speak to or interact with. Front desk job descriptions can vary depending on the industry. Greeting and receiving guests and customer service are usually a common thread in all front desk job descriptions. The job responsibility of front desk officers in UNMC for example, is not only assisting and providing solutions to customers, but also ensuring all details of university IT related services are up-to-date, accurate, efficient and effective within the campus. Responsibilities for a front desk officer often include answering a multi-line phone system and greeting and directing guests, as well as staff [250]. Furthermore, duties include responding to complaints, service issues and other general questions or concerns as appropriate. Most importantly, it is the responsibility of the front desk officer to capture all attended front desk requests/services into HMS.

The approach of the root-cause analysis adopted in this study was data analysis of the collected data to discern the patterns, tendencies and other factors associated with the problem to prove/disprove possible causes. The authors performed a deeper investigation of process analysis into understanding the performance level of front desk operation, with the aim to identify inconsistencies, highlight “disconnects” or problem areas that might cause or contribute to the low percentage of attended front desk requests/services being recorded into HMS. When these two strategies combine, it will highlight the real power of Six Sigma analysis [5, 7].

The analysis phase started with the team brainstorming all possible causes that might create the high level of bad deliveries. To take the investigation and analysis further, this study opted to work on a high level process map, a detailed process map (Input-Process-Variables) as well as a process flow chart as shown in Figure 59, Figure 60 and Figure 61. The list was narrowed down to several “prime suspects” using the Cause and Effect diagram or Fishbone diagram:

Table 76 Six Sigma Calculation (UNMC)

Source: Case study analysis compilation

Front Desk User-Account Services vs Total IS Services Defection

Description	Defect	Unit	Opportunity for error per unit *	No. of defects	No. of Units	DPMO	Sigma Level
Front Desk Attended User-Account requests/services not captured in HMS	User-Account Defect	Each User-Account Request/Service	1 per attended request / service	107 front desk attended User-Account requests / services were not captured into HMS	155 attended User-Account requests / services	$\text{DPMO} = \left\{\frac{107}{123}\right\} \text{x } 10^6$ = 869,918	0.374

Front Desk Wireless Services vs Total IS Services Defection

Description	Defect	Unit	Opportunity for error per unit *	No. of defects	No. of Units	DPMO	Sigma Level
Front Desk Attended Wireless requests/services not captured in HMS	Wireless Defect	Each Wireless Request/Service	1 per attended request / service	45 front desk attended Wireless requests / services were not captured into HMS	46 attended Wireless requests / services	$\text{DPMO} = \left\{\frac{45}{46}\right\} \text{x } 10^6$ = 978,261	-0.519

Front Desk Moodle/Portal vs Total IS Services Defection

Description	Defect	Unit	Opportunity for error per unit *	No. of defects	No. of Units	DPMO	Sigma Level
Front Desk Attended Moodle / Portal requests/services not captured in HMS	Moodle / Portal Defect	Each Moodle / Portal Request/Service	1 per attended request / service	78 front desk attended Moodle / Portal requests / services were not captured into HMS	95 attended Moodle / Portal requests / services	$\text{DPMO} = \left\{\frac{78}{95}\right\} \text{x } 10^6$ = 345,133821,053	0.581

Student Satisfaction Survey (Year 2010)

Description	Defect	Unit	Opportunity for error per unit *	No. of defects	No. of Units	DPMO	Sigma Level
Student Dissatisfaction for Helpdesk Support	Student Dissatisfaction	Each Survey Respondent	1 per respondent	123 dissatisfaction for helpdesk services	655 attended requests / services	$\text{DPMO} = \left\{\frac{123}{655}\right\} \text{x } 10^6$ = 187,786	2.286

Student Satisfaction Survey (Year 2011)

Description	Defect	Unit	Opportunity for error per unit *	No. of defects	No. of Units	DPMO	Sigma Level
Student Dissatisfaction for Helpdesk Support	Student Dissatisfaction	Each Survey Respondent	1 per respondent	237 dissatisfaction for helpdesk services	799 attended requests / services	$\text{DPMO} = \left\{\frac{237}{799}\right\} \text{x } 10^6$ = 296,621	2.034

Overall Front Desk Services vs Total IS Services Defection

Description	Defect	Unit	Opportunity for error per unit *	No. of defects	No. of Units	DPMO	Sigma Level
Front Desk Attended requests/services not captured in HMS	Front Desk Defect	Each Front Desk Request/Service	1 per attended request / service	246 front desk attended requests / services were not captured into HMS	557 attended requests / services	$\text{DPMO} = \left\{\frac{246}{557}\right\} \text{x } 10^6$ = 441,652	1.647

Overall Helpdesk Support Satisfaction Level

Description	Defect	Unit	Opportunity for error per unit *	No. of defects	No. of Units	DPMO	Sigma Level
Student Dissatisfaction level for Helpdesk Support	Student Dissatisfaction level	Each Survey Respondent	1 per respondent	360 dissatisfaction for helpdesk services	1454 attended requests / services	$\text{DPMO} = \left\{\frac{360}{1454}\right\} \text{x } 10^6$ = 247,593	2.182

- Most attended front desk IS Support request/services are not captured into the HMS.
- Tendencies of front desk officers to capture attended request/services which requires follow-up effort.
- Current front desk operational guidelines were not adequately enforced the capturing of attended requests/services into HMS.
- Lack of monitoring, control and tracking of attended Front Desk requests/services by the team leader.

Since the front desk IS Support Services are greatly dependent on valid Student-ID generated from EMS, the same investigation methods were carried out for Student Registration Process as shown in Figure 63, Figure 64, Figure 65 and Figure 67.

6.4.2 Tools and Techniques

Process Maps gives a general overview and business flow of front desk operation before moving into the details of each process [5]. *Input-Process-Variable* outlines the controllable (e.g. Front Desk Call-logging procedure) and critical (Call-log number, Call-log status) variables that contribute to each process of front desk activities [7]. *Flowcharts* represent an algorithm or process which are used in analyzing, designing, documenting or managing a process or program in various fields. This *Fishbone diagram* is a structured brainstorming approach for gathering ideas and inputs. Once the root-causes are outlined in the fishbone diagram, the author proceeds to the next level of investigation by performing *Failure Modes and Effects Analysis* (FMEA). FMEA is a qualitative technique approach [10] of an inductive failure analysis within a system and classification by the severity and likelihood of the failures. The FMEA procedure aims to identify every possible way in which a process, services or product might fail, rank on a scale of one to ten for those possible failures and probable causes, and prioritize solutions [81, 251].

In addition, this study prepared Cause-and-Effect diagram for Front Desk IS Helpdesk Support as well as for Username and Password retrieval; Figure 62 and Figure 66 respectively.

6.4.2.1 IS Front Desk Support

Figure 59 and Figure 60 provide a general overview of information flowing in and out within the IS Front Desk Support activities. Users are allowed to send in IT related request, enquiry and issues via email, phone calls or personally walk-in for front desk services. Any requests, enquiries and issues pertaining to IS Services will be logged into HMS with users' information (i.e. student name, student ID, date reported, time reported, responsible support staff, description of issue etc.) recorded for follow-up purposes. Once the ticket is captured into the HMS system, a unique ticket number will be assigned to each reported event. The helpdesk manager will then assign the reported ticket accordingly to respective technical and support staff for resolution follow-up based on individual areas of expertise. The assigned staff will attend to respective assigned ticket and any follow-up activities will be updated into the HMS on timely basis. The helpdesk manager will review call-log status on daily, weekly and monthly basis to ensure assigned tickets are attended, followed-up and resolved within the departmental assigned time frame. A step-by-step flow chart describing front desk IS Support activities is discussed in Figure 61.

By benchmarking collected input variables from Figure 59 and Figure 60, a listing of critical variables and controllable variables for respective sub-processes were tabulated in Table 77. The identification of critical variables in Table 77 is consistent with findings resulting from the measure phase, i.e. Logging Status of Request, Enquiry and IS Support related issue; Pattern of IS staffs attending call-logs and Call-log status review are the potential areas which the research team can focus on as opportunities for continuous improvement.

6.4.2.1.1 High Level Process Mapping

Source: Case study analysis compilation

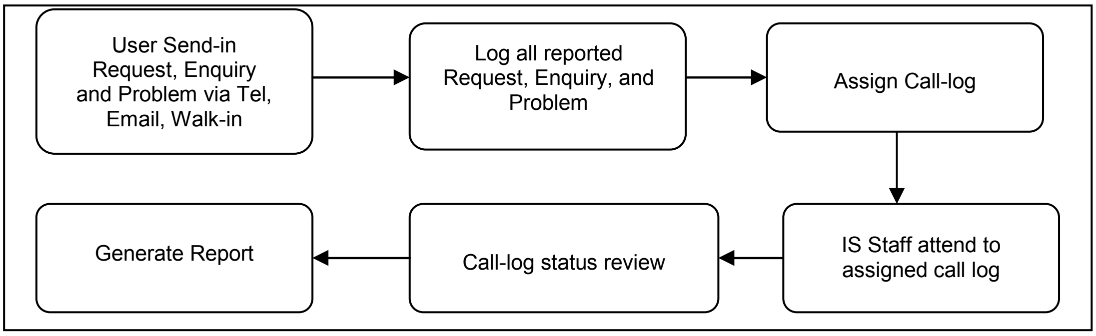


Figure 59 High Level Process Map – Front Desk IS Support (UNMC)

6.4.2.1.2 Input-Process-Variables

Table 77 Input-Process-Variable – Front Desk IS Support (UNMC)

Process	Critical Variables	Controllable Variables
Logging of Request, Enquiry and Problem	Call-log numbers	Call-log logging procedure
IS Staff Attending Call-log	Email follow-up	Accept/Reject call-log
Call-log status review	Call-log status	NIL

Source: Case study analysis compilation

Source: Case study analysis compilation

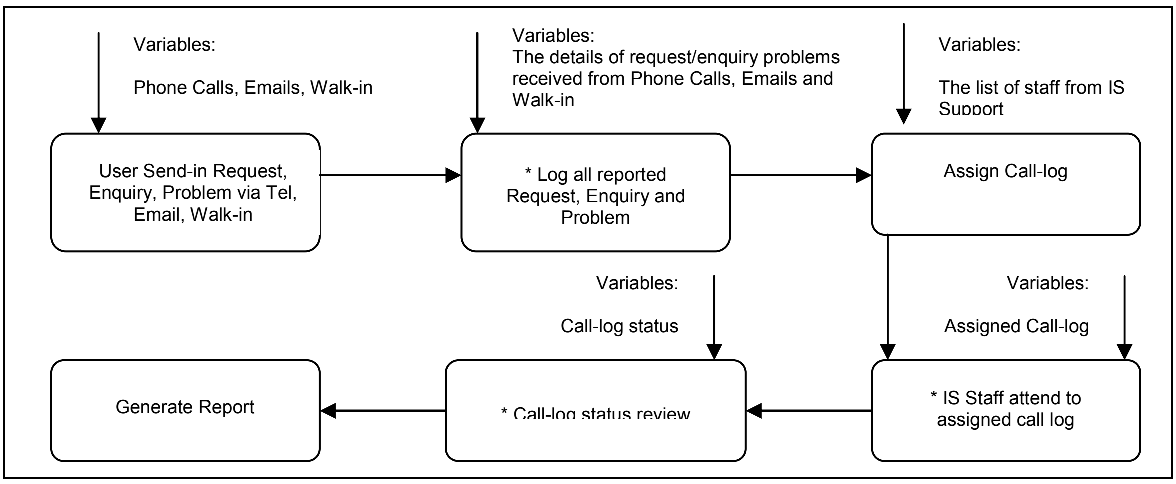


Figure 60 Input-Process-Variables Process Map – Front Desk IS Support (UNMC)

6.4.2.1.3 Cause-and-Effect Diagram

A "semi-structured interview" and "observation" was carried out to identify the root-cause of the potential problems which was identified in the earlier phase. In Figure 62, the five areas of business processes identified for investigation are Material, Measurement, Manpower, Procedure, Policies and Environment. The findings of *measurement* (i.e. (1) No proper call-log tracking mechanism; (2) Lack of staff ownership for assigned call-log), *materials* (i.e. (1) Some IS Services are dependent to third part company; (2) Only capture first incident and subsequent incident(s) are neglected) and *environment* (i.e. (1) Most IS related enquiries, requests and issues are resolved on-the-spot (2) Most IS related enquiries, request and issues required ad-hoc respond and attention) from the Cause and Effect diagram are consistent with statistics and theory compiled from the Measure phase. The area of "Manpower" and "Procedure/Policies" are the potential areas which have not been addressed in this investigation. The next step is to perform an in-depth analysis regarding how current operational work flow is affecting the overall resource allocations as well as work effectiveness and efficiencies.

6.4.2.1.4 Flow Chart

Source: Case study analysis compilation

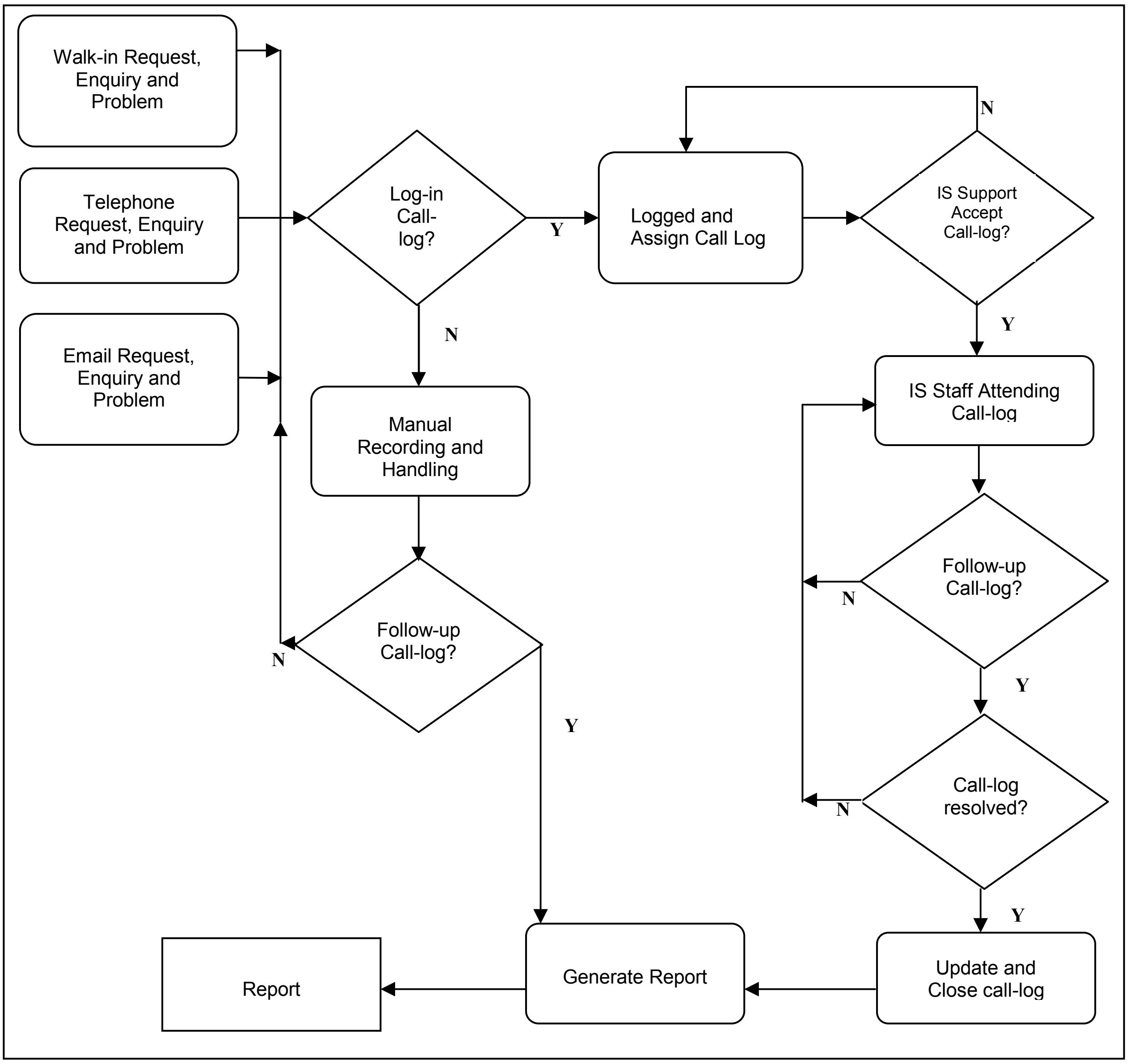


Figure 61 Flow Chart – Front Desk IS Support (UNMC)

Source: Case study analysis compilation

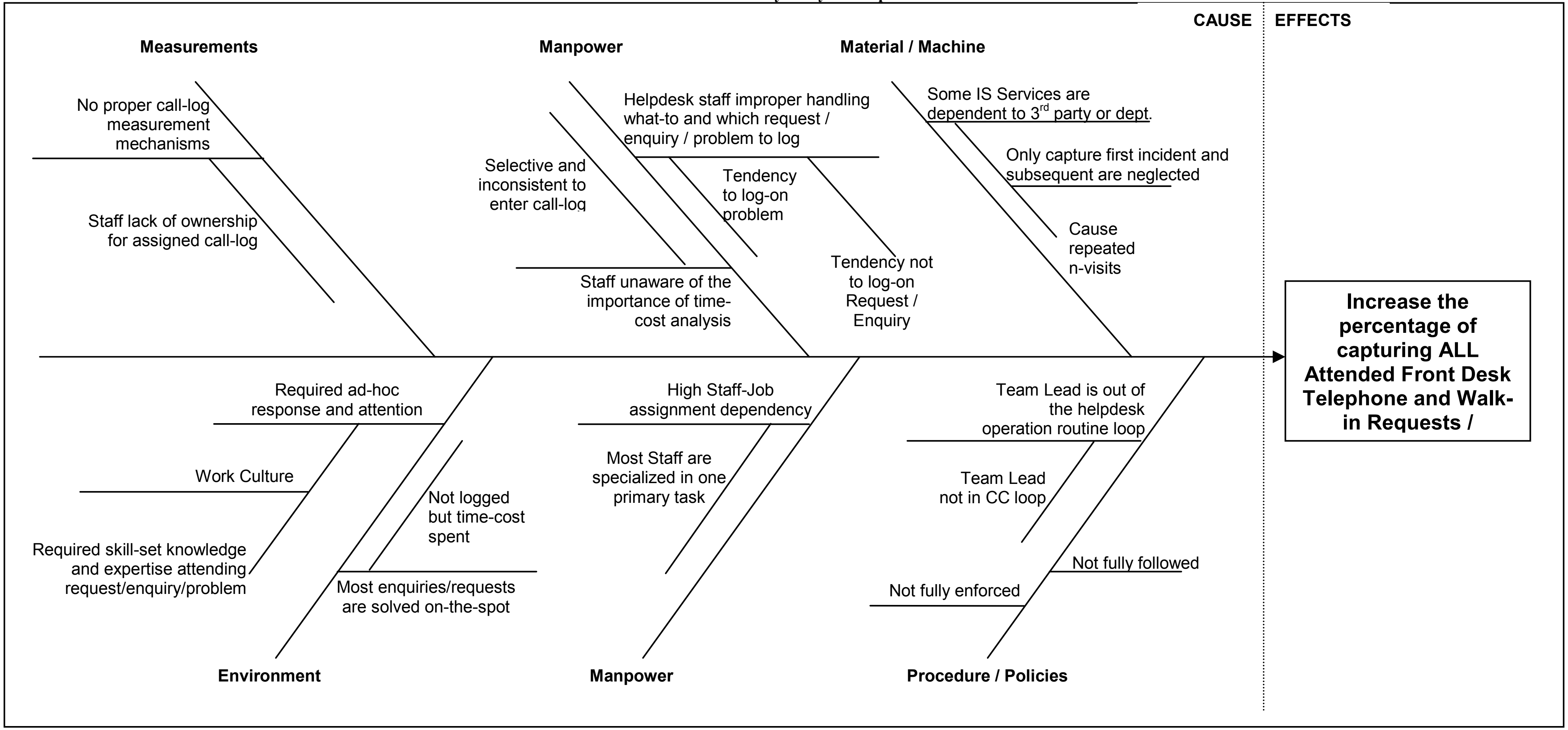


Figure 62 Cause and Effect diagram – Front Desk IS Helpdesk Support (UNMC)

6.4.2.2 Student Registration

As discussed in the Define phase, all IS Services are authorized with valid username and password. Student-ID generated from the EMS is used to generate username and temporary password and therefore it is necessary to analyze the Student Registration process as part of the input generation.

Figure 63 and Figure 64 provide an overview of student registration process and how registered new students will be assigned with valid student ID and internet user account. All the local and international students are required to verify themselves at the International department, Admission department and Finance department for course registration. The details of successful registered students will be captured into the EMS and a unique system generated Student-ID will be assigned to the registered student. With valid Student-ID, students may proceed to Security department for photo taking session; thereafter students may proceed to Accommodation office for lodging assistance. Only successful registered student will have internet access to UNMC internal circulation communication network. Students with valid Student-Id generated from EMS will have internet user accounts created automatically by the technical team of the IS Support UNMC. Upon creation of internet user account, every student requires to follow the “Username and password retrieval” guide to retrieve respective username and password. Students will be prompted with a set of rules and regulations (i.e. code of practice) for IS Support Services; and students required to read and accept the code of practice prior granted access to internet access. Once the student accepted the code of practice, students may proceed to access his/her own user account for any university level communication. A step-by-step flow chart describing front desk IS Support activities is discussed in Figure 65. By benchmarking collected input variables from Figure 63 and Figure 64, a listing of critical variables and controllable variables for respective sub-processes were tabulated in Table 78. The identification of critical variables in Table 78 is consistent with findings resulting from the measure phase where user account related call-log required “ad-hoc respond and attention” and “often not logged into HMS” which the research team can focus on as opportunities for continuous improvement.

6.4.2.2.1 High Level Process Mapping

Source: Case study analysis compilation

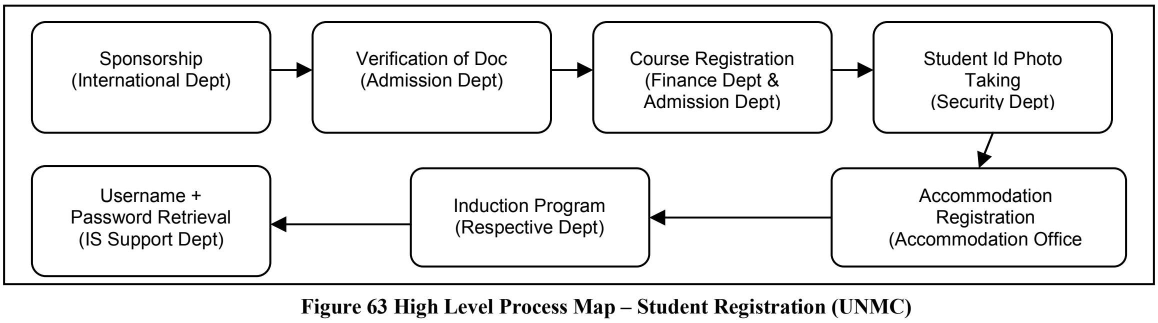


Figure 63 High Level Process Map – Student Registration (UNMC)

6.4.2.2.2 Input-Process-Variables

Source: Case study analysis compilation

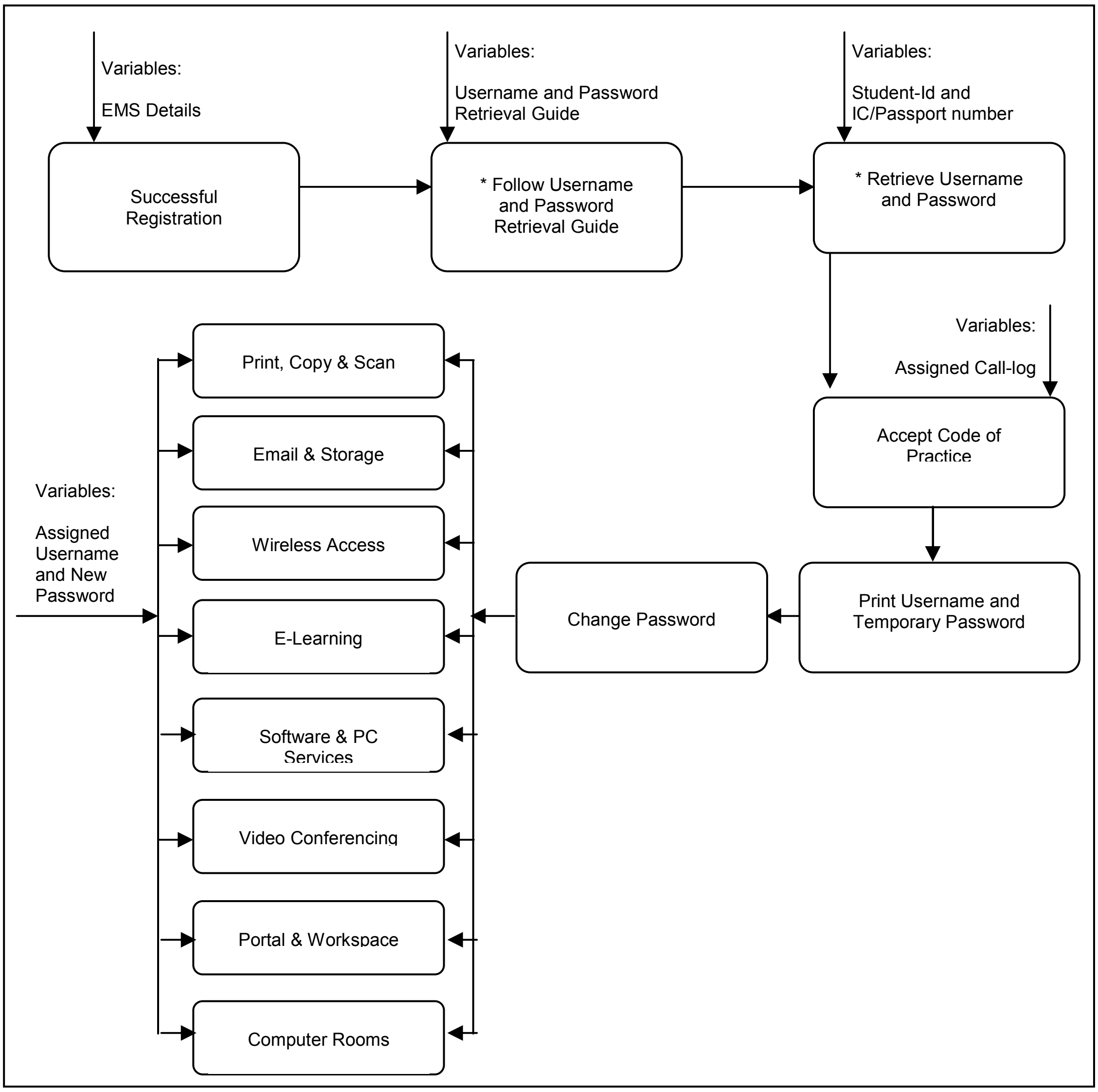


Figure 64 Input-Process-Variables – Student Registration (UNMC)

Table 78 Input Process Variables – Student Registration (UNMC)

Process	Critical Variables	Controllable Variables
Username and Password Retrieval Guidelines	Username and Password Retrieval Guide	• Internet knowledge • Username and Password Retrieval Guide
Username and Password Retrieval	• Student-Id • Passport and IC number	Induction Program

Source: Case study analysis compilation

6.4.2.2.3 Flow Chart

Source: Case study analysis compilation

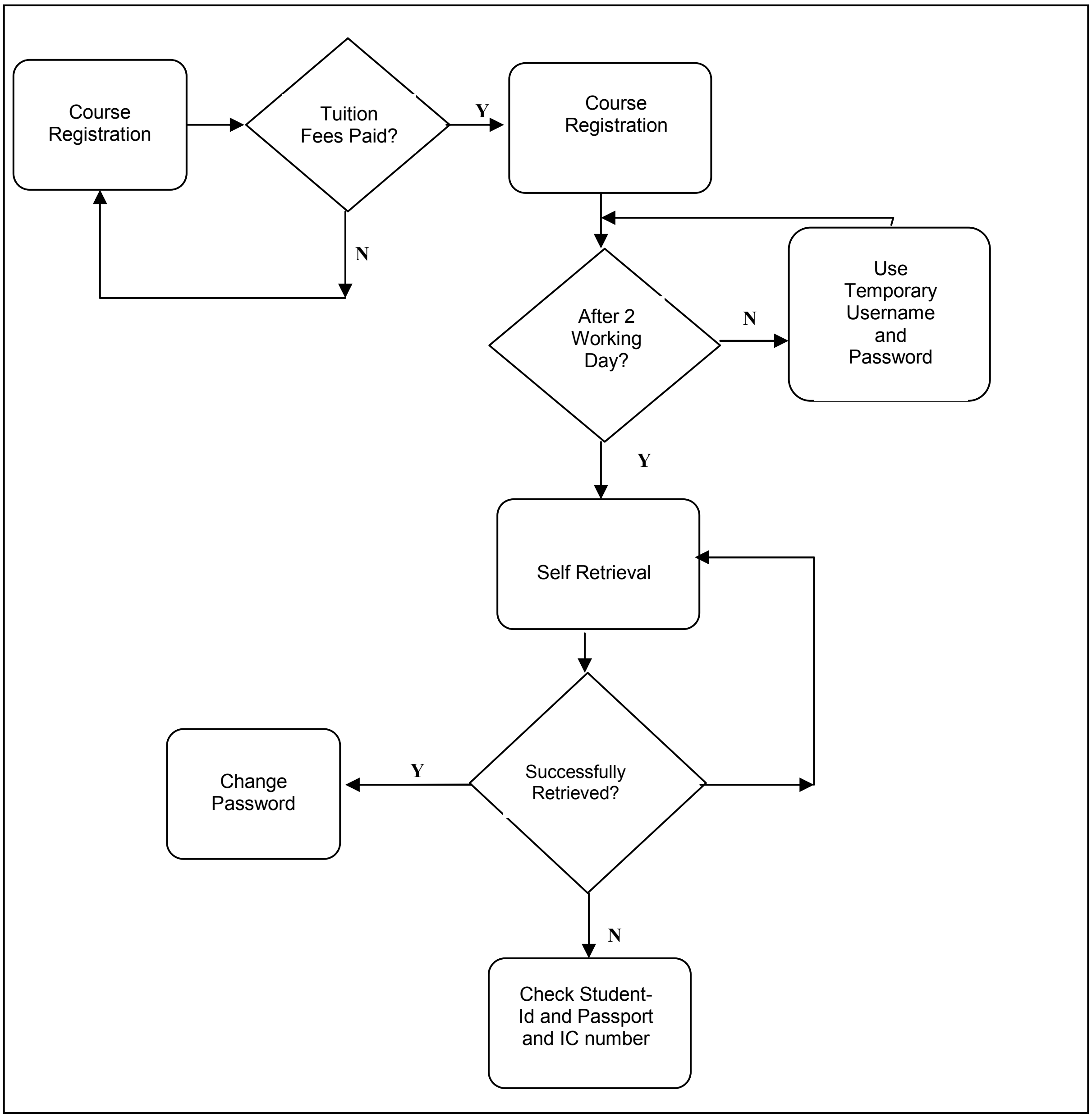


Figure 65 Flow Chart – Username and Password Retrieval (UNMC)

6.4.2.2.4 Cause-and-Effect Diagram

In Figure 66, the five areas of business processes identified for investigation are Material, Measurement, Technology, Procedure, Policies and Environment. The findings of *measurement* (i.e. Tendency not to capture on-the-spot resolved issue into HMS) and *environment* (i.e. Walk-in request required attentive and instant service) from the Cause and Effect diagram are consistent with statistics and theory compiled from the Measure phase. The area of “Manpower”, “Material”, “Policies” and “Procedure” are the potential areas which have not address in this investigation. The next step is to perform an in-depth analysis regarding how current operational work flow is affecting the overall resource allocations as well as work effectiveness and efficiencies.

6.4.2.2.5 Failure Modes and Effects Analysis (FMEA)

A FMEA is a qualitative technique approach [143] of an inductive failure analysis for analysis of failure modes within a system for classification by the severity and likelihood of the failures [19]. FMEA helps to identify potential failure modes based on past experience with similar products or processes or based on common failure mechanism logic, enabling to design those failures out of the system with the minimum of effort and resource expenditure, thereby reducing development time and costs [152, 252].

After two rounds of cause-and-effect brainstorming with Lotus Ng and Vivi, a list of root-causes captured for different failures were summarized into the FMEA. The potential causes for each failure are further analyzed and reviewed to ensure true root causes of the problem are identified. Vivi had provided the team with the risk priority number (RPN) from Table 57 guideline for each potential failure; RPN was computed and the potential failures were sorted in descending priority order (based on RPN) of importance for improvement suggestions. The FMEA for front desk IS Helpdesk Support are outlined in Table 79. In summary, the list of top five potential failures for IS Support UNMC in the order of importance are: (1) Tendency of log-in problem or call-log which requires follow-up only; (2) Long list of outstanding of un-resolved call-log; (3) Non-recorded attended IS Support Services such as “front desk user account” and “AV request/services”; (4) Not all walk-in or call-in requests, services and problems are logged and (5) No formal call-log measurement mechanism.

Source: Case study analysis compilation

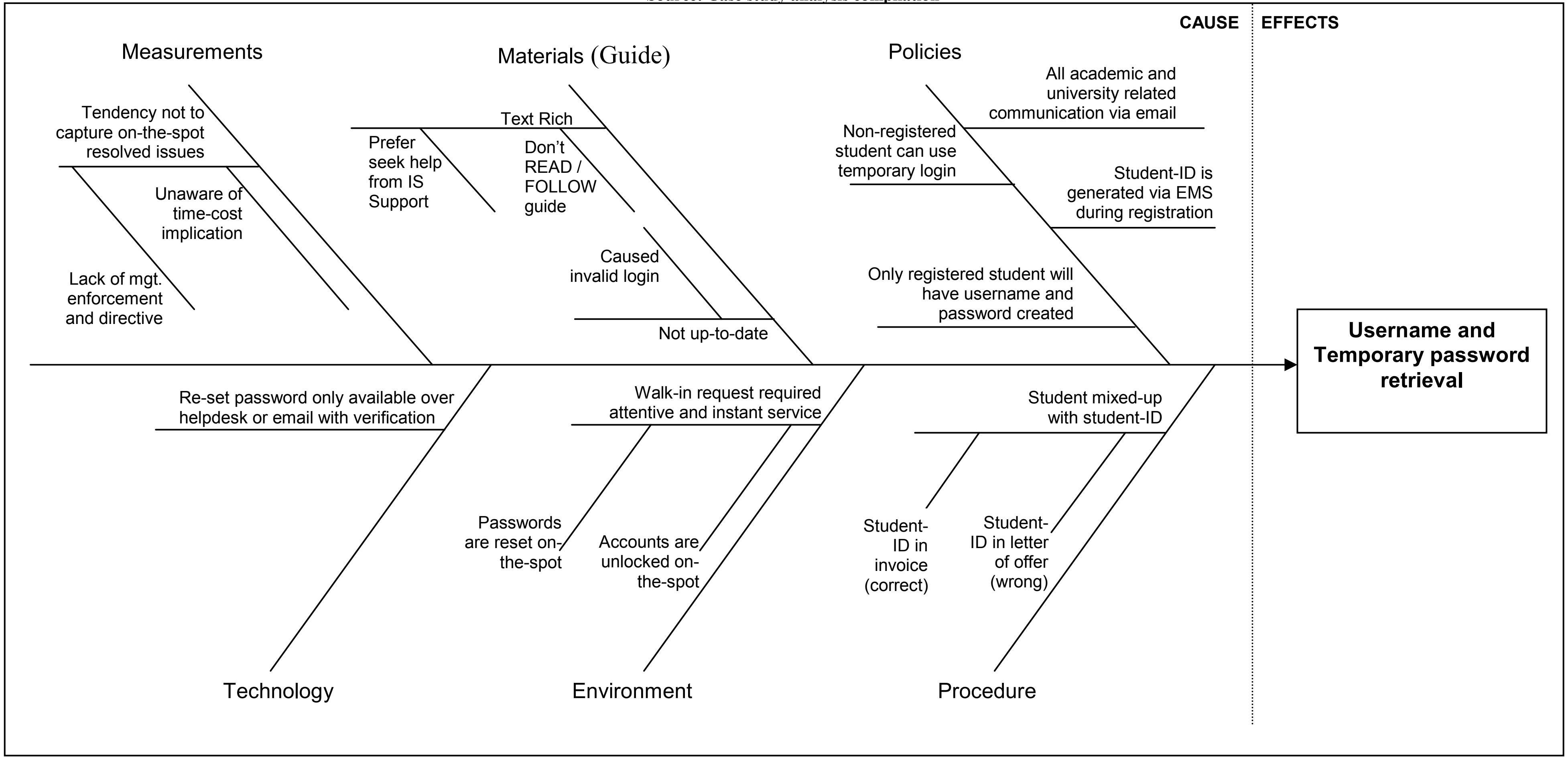


Figure 66 Cause and Effect Diagram - Front Desk IS Helpdesk Support – Username and Password Retrieval (UNMC)

Table 79 Failure Mode and Effects Analysis – Front Desk IS Helpdesk Support and Username and Password Retrieval (UNMC)

Potential Failure Modes	Potential Causes	Current Controls	Risk Priority Number (RPN)				Recommended Action
			Severity	Occurrence	Detection	RPN	
Tendency of log-in problem or call-log which requires follow-up only	Support Staff overlooked of departmental directives and objectives	No Control	6	5	4	120	• Process Procedure to include all call-log tracking, controlling and handling • Create awareness of helpdesk category inclusive of enquiry, request and incident • Make awareness the importance of time-cost tracking within the helpdesk support
Long list of Outstanding of un-resolved call-log	Lack of consistent follow-up	Weekly, Bi-weekly and monthly review	4	6	4	96	Insist on daily call-log review and report, where un-resolved or un-closed call-log is recorded to address any deviations and non-conformance up front
Non-recorded Attended Front Desk User Account Requests/Services	• Lack of enforcement • Required ad-hoc services • Attended requests/services are solved call-log which does not required follow-up	No Control	5	6	3	90	• Peak Time (Registration Week) - Log book or IS Service Request Form for ad-hoc tracking purposes which later transfer into HMS • Non-Peak Time – Direct log-on to HMS upon providing request/service
Non-recorded Front Desk Attended AV Requests/Services	• Lack of enforcement • Required ad-hoc services • Allowance of ±5 mins for response time	No Control	7	4	3	84	Log book or IS Service Request Form for ad-hoc tracking purposes
Not all Walk-in / Call-in requests, services and problems are logged	Request, service and problems are solved on-the-spot	No Control	4	7	3	84	• Development of process guidelines to capture walk-in request / services • To implement QA Tool
No formal call-log measurement mechanism	Lack of management enforcement	No Control	5	5	3	75	Development of procedure for internal quality assurance for non-compliance activities
Required to wait for TWO to FIVE working days for user account retrieval	• Staff-Dependent on username and temporary password creation • Student un-aware and don't understand the compliance of TWO working days	No Control	6	4	3	72	• Extend staff skill-set, knowledge and expertise allowing >1 staff handling user account creation • Highlight the earliest date of username and password retrieval
Non-recorded Front Desk Attended Wireless Requests/Services	• Lack of enforcement • Required ad-hoc services • Attended requests/services are solved call-log which does not required follow-up	No Control	3	7	3	63	Upload user guide to IS website Upload wireless setting file to IS website Upload screen-cam to website
High Job-assignment dependency	Lack of crossed expertise among resources	Specific-scope-tasks are staff dependent	5	5	2	50	Extend staff skill-set, knowledge and expertise to handle >1 task-area

Potential Failure Modes	Potential Causes	Current Controls	Risk Priority Number (RPN)				Recommended Action
			Severity	Occurrence	Detection	RPN	
Helpdesk staff in control of call-logs logging	Team lead oversees helpdesk but minimally involved directly in operational day-to-day activities	Random check in place	4	3	3	36	• Development of call-log control, tracking, monitoring for subject-related activities • Ad-hoc and random check is required
Username and temporary password retrieval guide is not user friendly especially for non-IT savy student	Guide is rich text	Specific-scope-tasks are staff dependent	2	3	3	18	• Suggest to have mixture of picture and text • Suggest of screen-cam or short video on username and temporary password retrieval
Delay in student registration (online vs manual)	• Due to limitation in EMS system, registration modes are online and manual • Manual registration caused delay and unassigned of Student-ID	No Control	8	2	1	16	Process Procedure to have manual registering student collecting official receipt from Finance and Admission department to obtain Student-ID
Confusion of Student-ID	Student-ID assigned in letter-of-offer and payment receipt is different	No Control	2	5	1	10	Development of process guidelines about formal Student-ID
Outdated username and temporary password retrieval guide	Disparity versions of guide between the department of IS, Finance and Admission.	Weekly, Bi-weekly and monthly review	4	2	1	8	• Include date and year in the section footer of the guide • Should only provide PDF format and should only be distributed by IS Department.

Source: Case study analysis compilation

6.5 Improve Phase

6.5.1 Introduction

In the Improve phase, the authors are looking for workable potential solutions that will maximize the benefits for the front desk effort. After 1.5 hours of brainstorming session with Ms. Vivi, the team had produced a list of possible actions and ideas which help addressing the root cause as well as achieve our goals. List of redundant ideas and actions were further eliminated and finally emerged with two broad categories of ideas (Table 80) in accordance to the Criteria Matrix (i.e. Causes and Effects Diagram) which produced in the Analysis phase: (1) Changing front desk work flow to improve captured percentage of attended front desk IS Support activities; (2) Suggesting ways to improve the efficiency and effectiveness of capturing attended front desk IS Support Services into HMS.

Table 80 Front Desk IS Support Improvement Plan (UNMC)

No	Ideas and Action	Responsible
1	Improving the percentage of capturing attended front desk IS Support Services into HMS by adopting "IS Support Request Form"	• Front Desk Officers • Helpdesk Manager / Leader
2	Broadening the awareness of culture change by recognizing the importance of front desk officers completing the "Front Desk Cycle Flow"	• Front Desk Officers • Helpdesk Manager / Leader
3	Improving operational enforcement procedure to front desk helpdesk support by increased monitoring, controlling and tracking of front desk activities on daily basis	• Helpdesk Manager • Helpdesk Leader
4	Introducing performance incentives for completing "Front Desk Cycle"	• Helpdesk Manager • Helpdesk Leader
5	Introducing front desk incident satisfaction survey on top of bi-annual students satisfaction survey	• Front Desk Officers • Helpdesk Manager • Helpdesk Leader
6	Shortening queue waiting time by adopting the "IS Support Request Form"	• Front Desk Officers • Helpdesk Manager • Helpdesk Leader
7	Maximizing the utilization of HMS to better responding to ad-hoc requests which require immediate attention	• Helpdesk Manager • Helpdesk Leader

Source: Case study analysis compilation

6.5.2 Improvement Action Plan (AP)

6.5.2.1 AP#1: Adoption of IS Support Request Form

This action plan is about improving the percentage of capturing attended front desk IS Support Services into HMS by adopting "IS Support Request Form". It is common that operation of front desk IS Support is time sensitive; assistance and attention is always on an ad-hoc basis. This is the main reason why front desk officers are eager to "clear the crowd" from the front desk to make space for next in-coming crowd. Due to this reason, most attended requests/services were left unrecorded and not reflected in the HMS.

Whenever the crowd arrives, students and staffs need to queue for their turn. While queuing, students and staffs can fill in the IS Support Request Form while front desk officers are attending others. This has reduced the queue waiting time and at the same time, the respective intended IS Services are captured in the new form where front desk officers can act immediately and effortless. Upon passing the filled IS Support Request form to the front desk officer, all necessary information needed to perform “a” request/service is recorded in the form and minimum further query is needed. In the event when font desk officers accidently omitted any attended request/service into HMS, he/she can trail the record by referring to the collected form. This method hopes to serve the need to “clear the crowd” from front desk, at the same time it is capable of capturing information for every single front desk request/service.

The IS Support Request Form (Figure 39) could acts as a medium of data collection whenever students and staffs are waiting for their turn. In the case when there is no crowd, front desk officer should request students and staffs fill in the form. This is due to front desk officers at any time can be disrupted by the next in-line queue. Hence, it is always best to have some record for future reference. It is a simple form where lists of high frequency IS Support Services (i.e. User-Account, Wireless, AV and Moodle/Portal) are available for selection to eliminate time needed to write down the request/service.

In the past, phone calls handling involved front desk officer writing down the request/service into rough paper. Information in the rough paper is used to perform the service. Once the services are completed, the rough paper is no longer needed or in-used. The rough paper can now be replaced by the IS Service Request form. No new procedures are introduced but the rough paper is to be replaced with the IS Service Request form.

This case study aimed to improve the percentage of capturing attended front desk IS Support Services into HMS by adopting “IS Support Request Form”. The overview workflow of how IS Service Request form fits into IS Front Desk Support Work flow is shown in Figure 67. Someone may argue that this action plan is non-value-adding to students and staff, but in the ears of IS Helpdesk Support, it does; indeed, it is value-adding as well as it is the core for any helpdesk services. HMS does not only improves operational efficiencies by reducing the time spent to rediscover previous incidents or problems; it also gathers information during the incident management to help spot problems, capable of identify root-cause of frequent recurring incidents by capturing information into the pool of knowledge-base. The ability of HMS in knowledge management as well as problem management has gained much popularity in the helpdesk industry.

Source: Case study analysis compilation

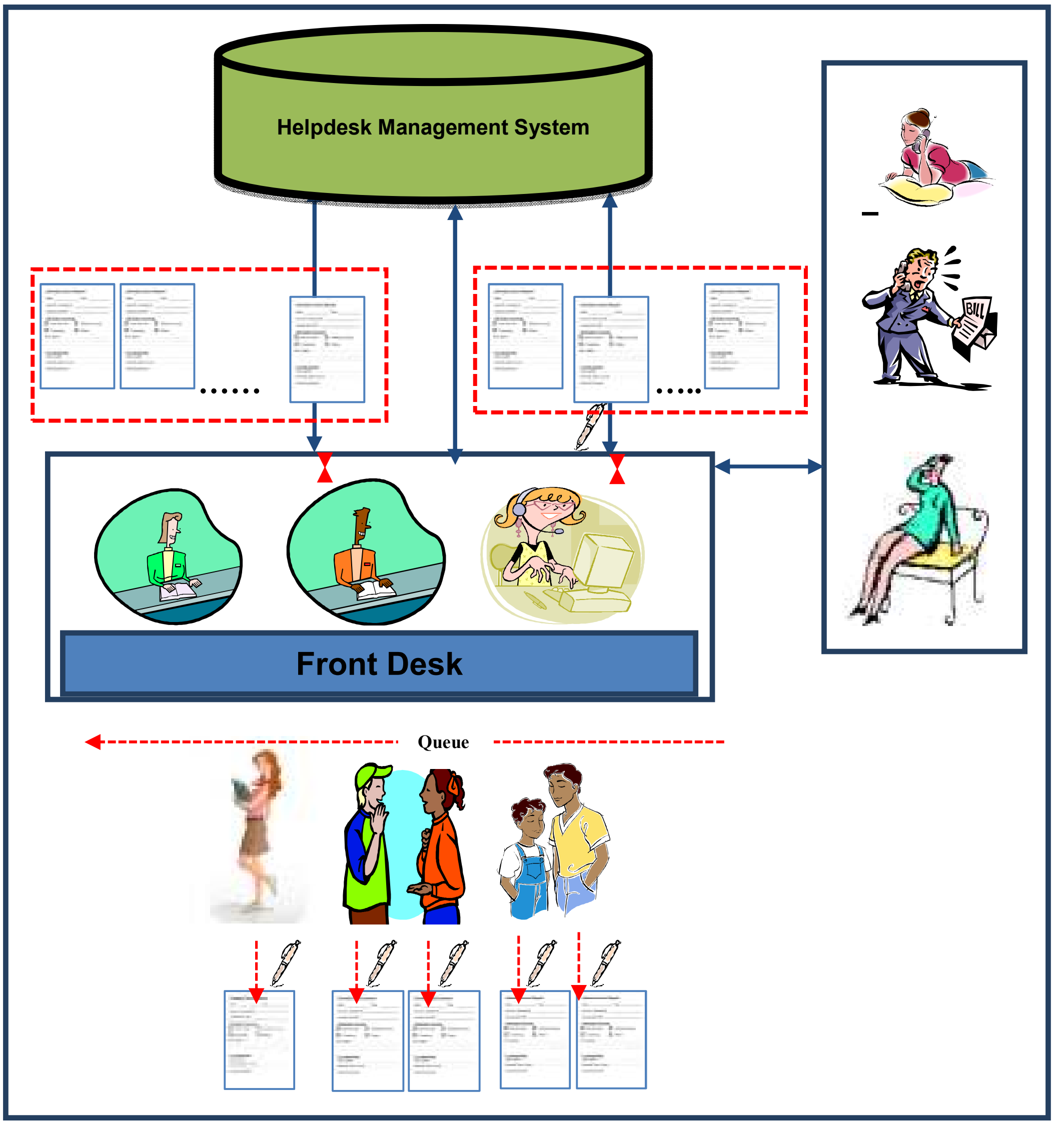


Figure 67 The Front Desk Workflow – New IS Service Request Form (UNMC)

6.5.2.2 AP#2: Broadening Awareness of "Front Desk Cycle Flow"

The research team aims to broadening the awareness of work culture change by recognizing the importance of front desk officers completing the "Front Desk Cycle Flow". It is important to raise the awareness of front desk officers understanding in completing front desk cycle for *every* attended request/service. The current Front Desk Cycle is outlined in Figure 68. The red rectangles with dotted line are the two important front desk activities which have been conveniently neglected most of the time.

The data collection in the Measure phase revealed 94% of front desk services are not captured into HMS. This implies there is a strong tendency of front desk officers by-passing the cycle activity of incident logging. Whenever there isn't any incident recorded in the HMS, there is no need to perform incident closure (which is indirectly omitted too). Hence, there is an urgent need to change the current way of front desk management. Currently, front desk officers are **partially completing the front desk cycle** (i.e. completing "attending request/service", "investigation, analysis and diagnosis" and "resolution" only) leaving behind the most important activity for helpdesk system, i.e. incident logging into HMS.

Source: Case study analysis compilation

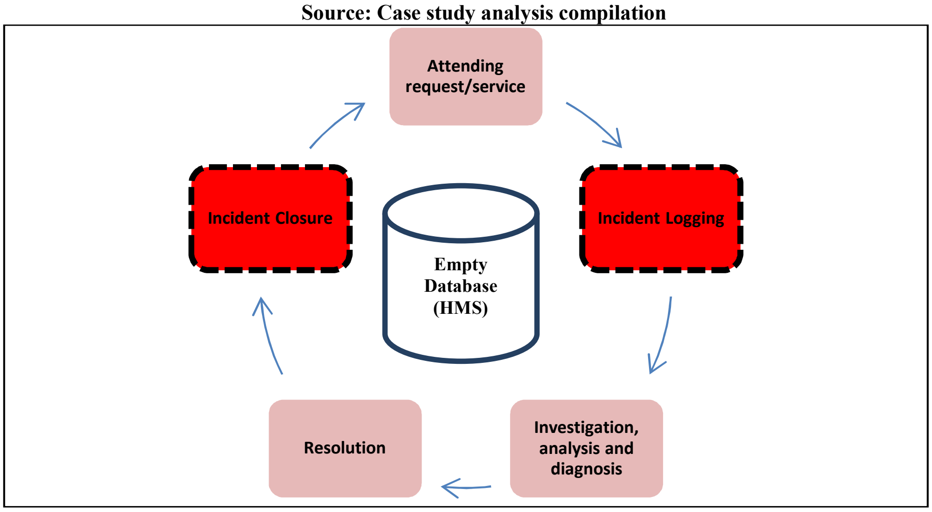


Figure 68 The Current Front Desk Cycle (UNMC)

The goal of introducing a new IS Service Request form is to better handling unpredictable front desk crowd whenever primary and ad-hoc attention is needed without wanting customers in long queue. The new proposed "Front Desk Cycle" does not change the existing cycle flow, but introducing a new form to assist information capturing as well as reducing queuing time (Table 81, Figure 69). The activities of new "Front Desk Cycle" are:

- **Student Filling IS Service Request form while queuing**
- **Attending request/service.**
- **Incident logging**. This is simply capturing attended request/service into HMS where system will auto-generate a unique call-log number.
- **Investigation, analysis and diagnosis**. Whenever an incident requires follow-up, this is the 'meat' of the process where assignees will try to understand how to restore service to users. It is important to note that resolution of any call-log should not be the only thing that front desk are considering as outputs, workarounds are useful to users in some cases (for instance, the resolution of the incident as possibly taking some time).
- **Resolution**. Once the incident is resolved and services are restored to users, details of the resolution should be reflected into HMS for future reference or sharing. IS Support may take note for future service enhancement.
- **Incident Closure**. Once the services is restored and request been fulfilled, respective front desk officer should close the incident.

Source: Case study analysis compilation

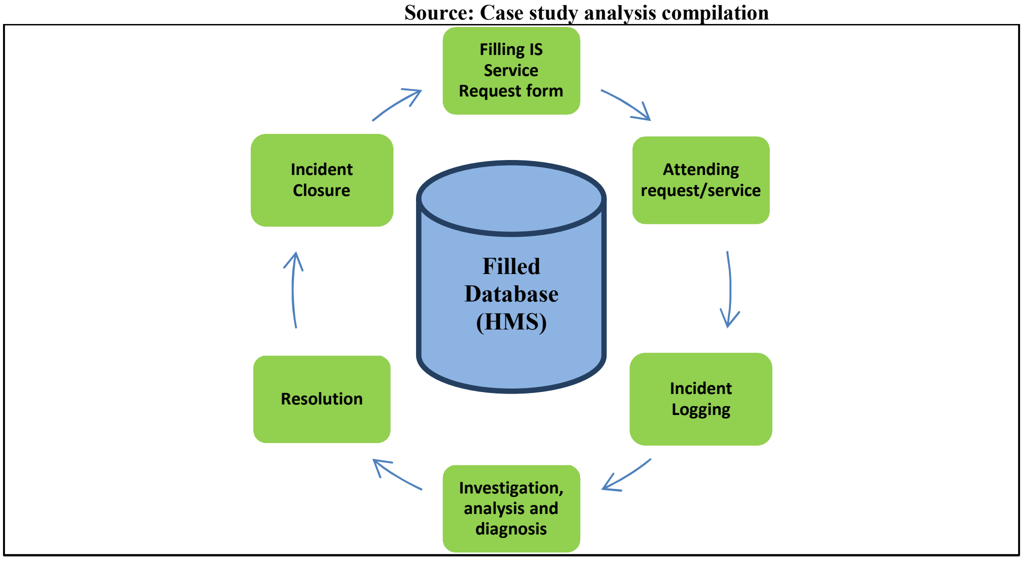


Figure 69 The Proposed Front Desk Cycle (UNMC)

Table 81 Activity Comparison of Current and Propose Cycle (UNMC)

No	Front Desk Cycle	Current	Propose
1	Filling IS Service Request form		√
2	Attending Student/Staff's request/service	√	√
3	Incident logging.	Partially	√
4	Investigation, analysis and diagnosis.	√	√
5	Resolution.	√	√
6	Incident Closure	Partially	√

Source: Case study analysis compilation

In conclusion, it is important to raise awareness amongst front desk officers the importance of **completing front desk cycle in sequence** without skipping any. The current front desk cycle is more of a "Manual Helpdesk Counter" where front desk officers only attending to request/service. The modern Helpdesk Management System provide us with actionable reporting which enables management to maximize the efficiency and effectiveness of IS Support team. This is the reason why all manual helpdesk counters had migrated to adopt Helpdesk Management System which allows trend information, such as reductions or increases on average incident resolution times, and performance against the Service Level Agreements and more to be produced effortless for decision making in timely basis. Hence, it is important to ensure departmental support in this positive work culture change for the benefits of the IT Department.

6.5.2.3 AP#3: Improve Front Desk Operational Enforcement Procedure

The next action plan is to improve operational enforcement procedure to front desk helpdesk support by increase monitoring, controlling and tracking of front desk activities on daily basis. Currently, there is a lack of monitoring, controlling and tracking of front desk activities. Majority of the attended Front Desk IS Support Services were left unrecorded; helpdesk metrics are unreliable and do not reflect true helpdesk capacity. Any good front desk guideline is always a "guideline on paper" if there is a lack of enforcement from first line management. From past experience, the processes of "incident logging" has always been neglected and it is crucial and yet necessary to perform timely monitoring, controlling and tracking. Since it is a work culture and human matters, formal daily and weekly review for front desk activities is necessary to give time for adjustment and room for learning curve.

It is always a good idea to gauge customer satisfaction against helpdesk metrics ensuring information captured during questionnaire feedback is constructively fair. In some cases, an integrated history of how an incident was handled can be valuable for everyone concerned in aid of decision making. The research team is not pushing for significant change, but rather a positive aspect of work culture change to complete the front desk cycle. To be fair to the organization, completing front desk cycle is part of front desk officers' job responsibilities but have been "left-out" overtime and turned into an unhealthy "work culture". There is no threat introduced in the new action plan but rather putting the front desk activities in place giving more effort into monitoring and tracking of incident logging task. The research team proposed this new approach to help bring about faster change and far easier implementation [253].

During the initial implementation stage, consistent monitoring and tracking by the team leader is important to ensure basic front desk cycle are completed. Although the current work culture keeps front desk officers away from logging into HMS, top down management and executive commitment and support from IT Department is the key to successful implementation. In addition, formal daily and weekly review for front desk activities should be scheduled on a daily basis and front desk daily routine should schedule the last half an hour of the day performing incident logging (if necessary).

6.5.2.4 AP#4: Front Desk Cycle Performance Incentive

It is important to introduce performance incentive for completing "Front Desk Cycle". The research team aware that any matters pertaining to human factors and work culture takes time to observe positive changes in place. Therefore, it is important to give the front desk team as well as all the helpdesk team specific goals to work toward, supported by significant rewards. There is a lot of skepticism around the way awards are devised, and this is not so easy to carry off, month after month, or quarter on quarter [253]. Hence, it is necessary to define performance goals, how to measure progress toward them, and how to reward people accordingly. In most circumstances, many leaders say they understand the concept of rewards, yet fall woefully short in executing this constructive action plan [254].

The existing HMS allows generation of statistic reports that support the performance challenges of incident logging and incident closure. The statistics counts for individual logged incident counts from HMS report clearly outline the efficiency and effectiveness of individual capability in completing the front desk cycle. It is not about bailing the front desk team to get a job done, but rather to motivate front desk officers to complete their front desk cycle which is part of their job responsibility. The incentive can come in the form of Starbucks vouchers, Movies tickets, Grocery vouchers etc. The research team targets the support team to view this reward system as a motivation factor to perform better; but not as an excuse to slack for other responsibilities.

6.5.2.5 AP#5: Front Desk Incident Satisfaction Survey

In view of continuous improvement, the authors are proposing an Incident Customer Satisfaction Survey for customers who walk-in and seek help from the front desk officers. The Front Desk Incident Satisfaction Survey emphasizes incidents basis rather than collective vague opinions. This incident survey identifies specific incident(s) which one experienced personally at front desk and which had an important effect on the final outcome.

A critical incident is defined as one which had an important effect on the final outcome and critical incidents can only be recognized retrospectively. Normally, the user is asked to focus on one or more critical incidents which they experienced personally in the field of activity being analyzed. In a typical incident management workflow, the respondent's response is able to correlate back to the incident and the analyst resolving the incident.

This study opted for summative evaluation. The incident activities (i.e. User Account, Wireless Services, E-Learning and others) are identified with intention to study, and get access to the users (e.g. Staff, students etc.) as soon as possible upon attended the services. As a result of the significant improvement of attended front desk cases being captured into HMS, the utilization of HMS as a performance indicator for the overall Helpdesk Centre is summarized in Table 82 which demonstrated an improvement of 92% after adopting the Six Sigma approach.

Table 82 Summative Evaluation – Incident Satisfaction Survey (UNMC)

IT Services	Very Satisfied (1)	Satisfied (2)	Neither Satisfied nor Unsatisfied (3)	Unsatisfied (4)	Very Unsatisfied (5)	No answer (6)	Top2	Bottom2
User Account	2	4	0	0	0	0	6	0
Wireless	6	4	0	0	0	0	10	0
E-Learning	3	6	0	1	0	0	9	1
Others	2	3	1	0	1	0	5	1
TOTAL	**32**	**17**	**1**	**1**	**1**	**Total**	**30**	**2**
						Total (%)	**94%**	**6%**

Source: Case study analysis compilation

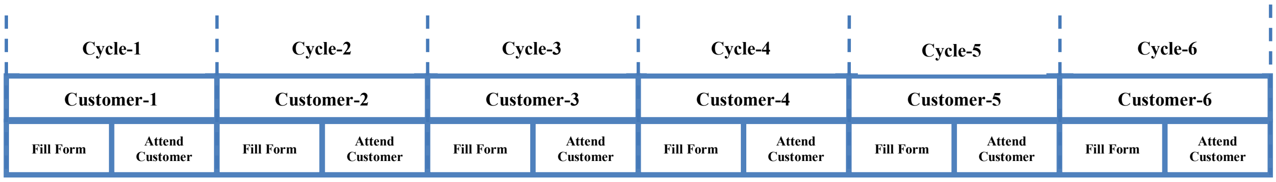
6.5.2.6 AP#6: Shortening Queue Waiting Time

A group of six customers approached Front Desk seeking assistance in E-Learning related activities. All customers are asked to fill in the IT Request form while in the queue. The adoption of the IT Request form has reduce the queue waiting time where the process of form fill-in was done in parallel instead of round-robin manner; where next-in-line customer fills in the form while front desk officer is attending to a customer. IT Request Form has shortened the queue waiting time by 2.5 cycle time (from cycle time of 6 to 3.5) and increase front desk officers availability by 42%. In other word, the idle-time of front desk officers waiting for next-in-line to fill-in the form has been reduced 14% against 50% prior the improvement plans.

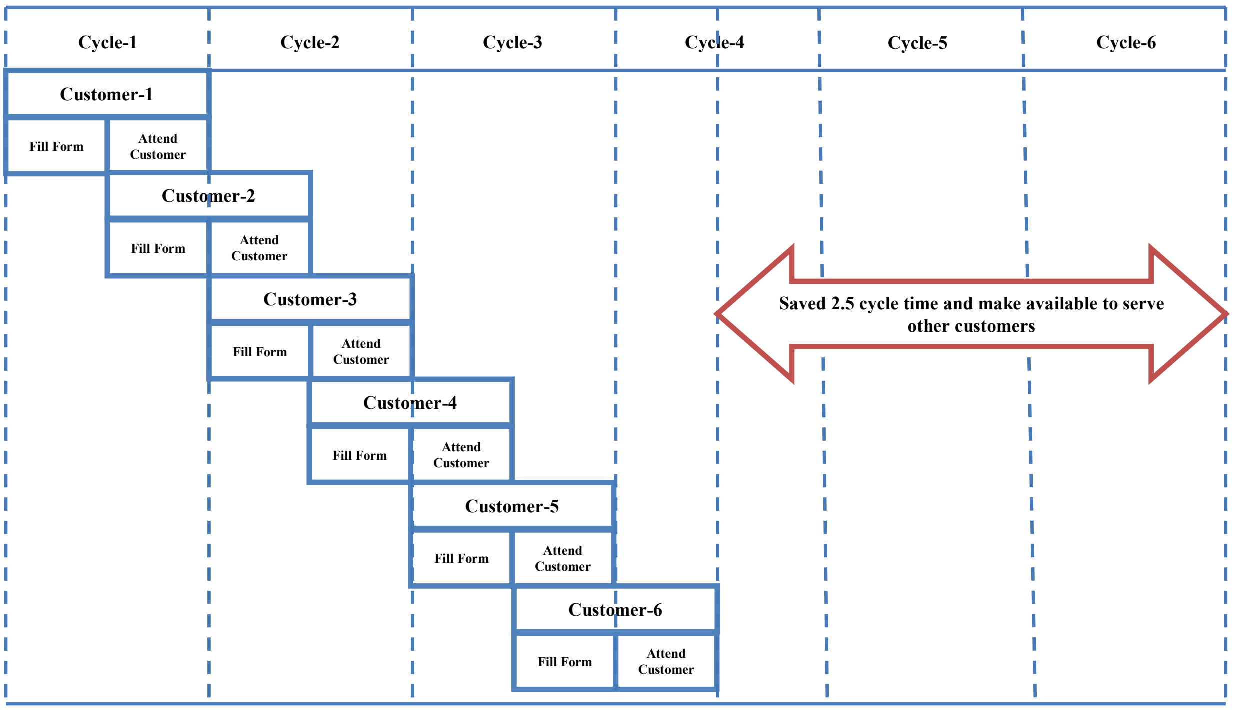
<u>Before IT Request Form Implementation</u>

Time taken to fill an IT Request Form = 30 seconds.

Time taken to fill an IT Request Form for 6 customer = 6*30 seconds.



<u>After IT Request Form Implementation</u>



Cycle Time improvement = 6 cycle time – 3.5 cycle time = 2.5 cycle time.
Before Improvement: Front Desk Officers idle time waiting for information = 6/12 = 50%
After Improvement: Front Desk Officers idle time waiting for information = 1/7 = 14%

6.5.2.7 AP#7: HMS Utilization

The preliminary investigation revealed that the IS Support is experiencing an inefficient time-cost budgeting on front desk activities due to the lack of effort in capturing attended IT requests/services into HMs. As a result, reports generated from the HMS do not reveal the actual performance of the helpdesk team, which further complicates resource management and utilization in better responding to any ad-hoc requests which required immediate attention.

As a result of significant improvement of attended front desk cases being captured into HMS as shown in Table 83, the utilization of HMS as a mean of performance indicator for the overall Helpdesk Centre demonstrated an improvement of 92% after adopting Six Sigma approach. This improvement contributed an important business indicator to front desk's effectiveness and and efficiency.

Table 83 HMS Utilization (UNMC)

Measurement Metric	Before Improvement	Six Sigma Improvements
Non-capture call-log into HMS	230	15
Captured Call-log into HMS	218	228
Total Attended call-log (Front Desk and Email)	448	243
Volume Accuracy of Helpdesk Activity (%)	218/448 = 49%	228/243 = 94%

Source: Case study analysis compilation

6.5.3 Six Sigma Implementation Outcomes

As discussed earlier, Six Sigma is a QIM which focuses on QA and QC. The case study has undergone the Define, Measure and Analyze and Improve phases; it is time for Six Sigma to process and test output which provide performance indicators as a result of implementing ideas/action-plan proposed to the Improve phase. To achieve this, an additional round of front desk on-the-job-observation was carried out over six-days and results are showed in Table 84 and the respective Sigma level is summarized in Table 85.

Table 84 Summary of Attended Front Desk Services Status into HMS (Six Sigma Approach)

	User Account (Tel/Walk-in)			AV (Tel/Walk-in)			Wireless Access (Tel/Walk-in)			E-Learning (Tel/Walk-in)			Other (Tel/Walk-in)		
Day	*F/D*	*Map into HMS*	*Non-recorded (%)*	*F/D*	*Map into HMS*	*Non-recorded (%)*	*F/D*	*Map into HMS*	*Non-recorded (%)*	*F/D*	*Map into HMS*	*Non-recorded (%)*	*F/D*	*Map into HMS*	*Non-recorded (%)*
Day-1	0	0	0%	0	0	0%	1	1	0%	1	1	0%	5	5	0%
Day-2	1	1	0%	0	0	0%	0	0	0%	0	0	0%	7	5	29%
Day-3	3	2	33%	5	5	0%	3	2	33%	4	4	0%	6	4	33%
Day-4	2	2	0%	4	4	0%	1	0	100%	0	0	0%	2	0	100%
Day-5	4	3	25%	3	3	0%	3	2	33%	4	4	0%	1	0	100%
Day-6	1	0	100%	5	5	0%	2	2	0%	12	10	17%	0	0	0%
Total	**11**	**8**	**27%**	**17**	**17**	**0%**	**10**	**7**	**30%**	**21**	**19**	**10%**	**21**	**14**	**33%**

Source: Case study analysis compilation

In comparing Table 74 against Table 84, results in Table 84 showed that a significant improvement was achieved after adopting the systematic measurement process of Six Sigma DMAI-C process. The sigma level for User Account (Table 85) has improved to 2.105σ as opposed to 0.374σ, Wireless Access to 2.024σ as compared to -0.519σ s previously, E-Learning achieved 2.809σ from 0.581σ recorded in the earlier cycle. Other Services on networking issues was captured during the on-the-job-observation show a positive sigma level of 1.931.

Table 85 Six Sigma Calculation – Improve Phase (UNMC)

Front Desk User-Account Services Defection							
Description	***Defect***	***Unit***	***Opportunity for error per unit ****	***No. of defects***	***No. of Units***	***DPMO***	***Sigma Level***

Front Desk Attended User-Account requests / services not captured in HMS	User-Account Defect	Each User-Account Request/Service	1 per attended request / service	3 front desk attended User-Account requests / services were not captured into HMS	11 attended User-Account requests / services	$\text{DPMO} = \left\{\frac{3}{11}\right\} \text{x } 10^6$ = 272,727	2.105
Front Desk Wireless Services Defection							
Description	***Defect***	***Unit***	***Opportunity for error per unit ****	***No. of defects***	***No. of Units***	***DPMO***	***Sigma Level***
Front Desk Attended Wireless requests / services not captured in HMS	Wireless Defect	Each Wireless Request / Service	1 per attended request / service	3 front desk attended Wireless requests / services were not captured into HMS	10 attended Wireless requests / services	$\text{DPMO} = \left\{\frac{3}{10}\right\} \text{x } 10^6$ = 300,000	2.024
Front Desk E-Learning Defection							
Description	***Defect***	***Unit***	***Opportunity for error per unit ****	***No. of defects***	***No. of Units***	***DPMO***	***Sigma Level***
Front Desk Attended E-Learning requests / services not captured in HMS	E-Learning Defect	Each E-Learning Request / Service	1 per attended request / service	2 front desk attended E-Learning requests / services were not captured into HMS	21 attended E-Learning requests / services	$\text{DPMO} = \left\{\frac{2}{21}\right\} \text{x } 10^6$ = 95,238	2.809
Front Desk Others Services Defection							
Description	***Defect***	***Unit***	***Opportunity for error per unit ****	***No. of defects***	***No. of Units***	***DPMO***	***Sigma Level***
Front Desk Attended Others IT requests / services not captured in HMS	Others IT Requests/Services Defect	Each Others IT Request / Service	1 per attended request / service	7 front desk attended Others IT requests / services were not captured into HMS	21 attended Others IT requests / services	$\text{DPMO} = \left\{\frac{7}{21}\right\} \text{x } 10^6$ = 333,333	1.931

Source: Case study analysis compilation

A list of performance improvements were observed as a result of the implemented action plan of the Six Sigma DMAIC approach:

- The achievement of Incident Satisfaction Survey showed 94% of responses being rated at top two boxes of satisfaction level (i.e. Very satisfied and Satisfied) for User Account, Wireless Access, A/V and E-Learning; only a minority 6% are unsatisfied with the front desk services.
- IT Request Form has shortened the queue waiting time by 2.5 cycle time (from cycle time of 6 to 3.5) and increased front desk officers availability by 42%. In other word, the idle-time of front desk officers waiting for next-in-line to fill-in the form has been reduced 14% against 50% prior to the improvement plans.
- As a result of the significant improvement of attended front desk cases being captured into HMS, the utilization of HMS as a performance indicator for the overall Helpdesk Centre demonstrated an improvement of 92% after adopting the Six Sigma approach.

6.6 Control Phase

As to complete the DMAIC cycle of the Control phase, a mean of continuous improvement initiatives with one more or few more rounds of on-the-job-observation should be carried out to ensure consistency and maturity of work culture of front desk officers in completing the helpdesk operational cycle by capturing attended front desk requests/services into HMS. This can be achieved by validating, monitoring and controlling of front desk operational routine by developing standards and procedures to ensure overall Six Sigma methodology is sustainable for now and in the future. Two rounds of on-the-job-observation initiatives were carried out for the intake of July 2013 (i.e. 5-days duration) and September 2013 (i.e. 10-days duration due to main annual intake) to mark the continuous improvement of Six Sigma implementation in the IS Support department. The significant improvement of sigma level for the three major IT Services (i.e. User Account, Wireless Access and E-Learning) is summarized into Table 86 to allow benchmarking as a result of Six Sigma implementation.

Table 86 Six Sigma Calculation – Control Phase (UNMC)

Type of IT Service	Analysis Phase	Improve Phase	Control Phase	
			July 2013	September 2013
User Account	0.374 σ	2.105 σ	3.001 σ	3.107 σ
Wireless Access	-0.519 σ	2.024 σ	2.467 σ	2.586 σ
E-Learning	0.581 σ	2.809 σ	2.809 σ	3.093 σ

Source: Case study analysis compilation

The round of on-the-job-observation for July 2013 intake has proven significant improvement in sigma level for the three major IT services; with each reported with 42.6% and 21.9% improvement respectively for User Account and Wireless Access; and E-Learning remain unchanged in sigma-level achievement. Although there is only a slight improvement observed in the September 2013 intake (i.e. 3.5% for User Account, 4.8% for Wireless Access and 10.1% for E-Learning), these improvements indeed marked the progression of continuous improvement ensuring the essentials of sustained long term improvement. This important milestone kick-start a mechanism which ensures IS Support UNMC will make measures and improvement on daily, weekly and monthly basis, not just an occasional task.

6.7 Chapter Summary

The improved outcomes from the case study clearly proved that Six Sigma indeed has great potential and is worth the additional effort and time to explore and investigate to achieve operational excellence as well as measurement of performance indicator. The main advantage of Six Sigma over other QIMs is that it places significant emphasis on measurement and statistic to ensure that projects are properly set up and measured. In this case study, it is proven that when Six Sigma methodologies are applied properly, it could leads to concrete improvements where the fundamental basis of any decision has been explored and proven in detail.

Chapter 7 - Case Study: Company-C

7.1 Introduction

The case study company (Company-C), was established in September 2002. Company-C specialized in designs, installations, operations and maintenances of IT services and provides bespoke solutions for multinational companies, government agencies and private companies. These services include system architecture design, installation and deployment, IT technical onsite support, warranty support, maintenance, software support, helpdesk support, IT outsourcing and managed services, IT professional services and asset management.

Company-C has established a network of eighteen service support centers strategically located in all major cities across Malaysia. Its current workforce encompasses more than 100 skilled and experienced professionals including 80 technically trained specialists. Company-C has global strategic alliance with some of the major IT service providers to provide local support and services. The case study company has been complying and adhering to global practices and processes set by these global service providers. It is the business intent of company to work closely with their customers and partners to ensure that maximized gain can be obtained from the technology investment.

7.1.1 Business Intent

The main types of IT Services provided by the case company are summarized in Table 87:

Table 87 Business Area – Company C

Business Area	Type of Business	Business Activities
Consultancy Services	**Mobility**	Deliver mobility solutions which are secure, reliable, resilient, cost-effective and (most of all) sensible. Wherever the workforce is, be it working from home, an Internet café or a customer site, anywhere in the world
	Disaster Recovery	Offer professional services to its customers in the formulation of backup and disaster recovery policies. Additional services in this category include capacity planning, solution development and design as well as project management of the storage system
	System Migrations & Relocations	Minimize downtime when relocating equipment to another site or even within an existing premise. The highly skilled team has unrivalled expertise in the production print and mailing environments capable of taking end-to-end responsibility for the whole relocation project to avoid potential complexity involved in decommissioning and re-commissioning equipment.
	Server Centric	Deliver a server-based system which is fit for the purpose. Whether it's a simple small business server in a branch office or a Microsoft Exchange deployment through to a global Active Directory roll-out, with complex design implications
Managed Services	**Managed Support (Maintenance & Support Services)**	Provide technical and helpdesk support personnel to many industries. The team have provided floor-walking support, and one-to-one support for individuals, at all levels from the Boardroom to Boiler room
	Multi-Vendor Services (MVS)	Partnership with manufacturer and principal vendor of Maintenance contract to provide onsite troubleshooting and support
	SMEs Services	Bridge the gap and to deliver enterprise-class solutions and service to the its customers inclusive of tailored support experience to fit the exact requirements of client
	Outsourcing Services	The rich pool of resources forms the backbone of Company-C service provision enables the case company to deploy competent and knowledgeable staff whenever possible. With services spanning nationwide, all support staff are trained at an equally high level and are equipped with a wide range of experience from a large cross-section of industries
Infrastructure Services (Network Support)	**Local Area**	Design, build, implement and manage (if required) the whole LAN infrastructure.
	Wide Area	Provide a clear view on available options, (e.g. ADSL/SDSL, ISDN, Leased Lines, Remote Access, Virtual Private Network (VPN)), along with the benefits and drawbacks
	Wireless	Deliver secure, reliable, flexible and wireless networks which are resilient to failure. All wireless solutions are analyzed, designed and configured to meet the requirements of the organization exactly

Business Area	Type of Business	Business Activities
Security	Employee Internet Management (EIM)	Monitor and detect policy violations across the full spectrum of Web-based content: IM, P2P, streaming media, file downloads and Web-based e-mail
	Patch Management	Ensure Patch Management strategy slots into the operations of client's business and that client have a streamlined and measured approach to problems associated with on-going service maintenance.
	SPAM Management	Provide protection from all sort of risks associated with spam e-mail through effective spam management.

Source: Case study analysis compilation

7.1.2 Organization Chart

Company-C is adopting the hierarchical organizations structure with higher ranking individuals situated atop the chart (Figure 70). It is a resource-scarce SME with more than 100 employees in eighteen service centers.

Source: Case study analysis compilation

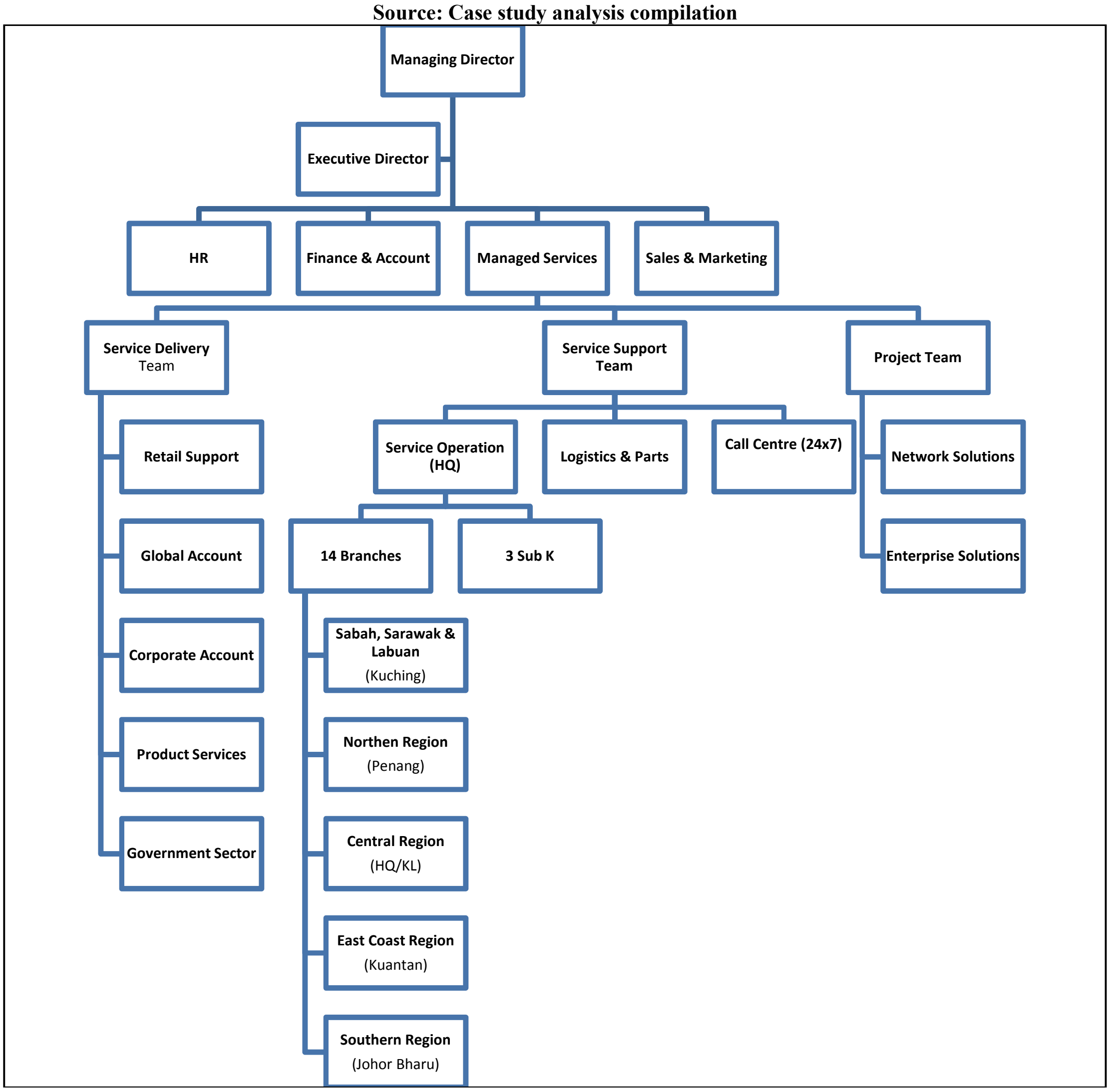


Figure 70 Company-C: Organization Chart

7.2 Define Phase

7.2.1 Introduction

The Business Groups of Company-C develop customer driven solutions on a project basis, using in-house solutions and concepts along with third-party technologies. In line with the focus on customer specifications, Company-C has a selection of its most important vertical markets: PC manufacturer, principle supplier of IT products, Telecommunication, Retail, Banking, Media and Transport, Government and Non-profit organization. This vertical market approach adds an extra dimension to the range of services provided by Company-C where customers can benefit from Company-C's ICT knowledge in addition to experience of the specific business processes of customers.

The case Company's strength lies in the range of its specialist services and its ability to combine and integrate various technologies and services. It offers its customers the opportunity to source a broad range of world-class sector-specific solutions and services with the additional benefit of a single operator. With more than 100 employees in 18 growing service centers and operating on 24 x 7 modes, Company-C is capable to provide a wide range of solutions and services within the region. Company-C provides a single point of contact where strong emphasis on people, technology and process through structured selective recruitment and investment in the continuous development of staff in supporting of their role as IT Service Provider.

The scope of activities in the Define phase include analyze, investigate, measure and improve the operational process of utilizing a pool of engineers in meeting agreeable service level agreement (SLA) to minimize redundancy, rework, budget overrun (e.g. increase of re-visit tickets) and at the same time to maximized resource utilization.

Preliminary analyses on the procedure and process flow of Company-C activities were collected via interview, observation and on-the-job training. The initial understanding of the operational process flow kicked start with interviewing the following management personnel:

- Mr. Tan, the Executive Director of Company-C. Mr. Tan's role as a consultant to assist the Managing director to oversee the overall business performance of Company-C (e.g. consultancy services, managed services, outsourcing services, infrastructure, security etc.) and any company-wide activities.
- Ms. Wong, the Operational Manager who oversees all aspects of vendor-client activities (i.e. meeting SLA) such as consultancy services, managed services, outsourcing services, infrastructures, security etc. Her role is to ensure all agreeable SLAs are met for all vendor-client account by effectively and efficiently allocating limited pool of resources (i.e. engineers) to resolve all issues raised by all vendor-client accounts in the shortest possible resolution time frame.
- Ms. Nuril, the helpdesk supervisor assisting the operation manager. She is the main contact who acted as a communication medium between the pool of engineers and vendor-client

contacts. Her role is to consolidate, manage, control, monitor and communicate each service for all the company's business intent. This department is operating in 24/7 business hour in lieu of supporting vendor-client operating 24/7 daily.

The collective analysis outcomes gathered from the management panel has drawn the research team's attention to the business area of "outsourcing services" which is critical and requires urgent attention for improvement as customer satisfaction is deteriorate since the start of the project in November 2012.

7.2.2 Definition of Outsourcing Services

Prior to discussing the operational definitions of CTQs and project variables for the case company, it is important to emphasize the following definitions in the business context of the nature of break-fixes activity for the case study company:

- **Service Level Agreement (SLA).** SLA is a formalized contract negotiated between service providers and service consumers which constitute a formal agreement about the consumption of a service.
- **Response Time.** Response time usually refers to how quickly the case company will respond to a reported ticket (e.g. technical, network, software issue) via phone, email or other methods. In the context of break-fixes activities, response time is the time taken by case company to provide Estimate-Time-Of-Arrival (ETA) to its clients.
- **Response SLA.** The agreeable time frame/duration taken by the case company to provide an agreed respond on ETA is the Response SLA or Response Time SLA.
- **Resolution Time.** A resolution time refers to how long it takes from the time an issue is logged and reported until it is fully resolved.
- **Resolution SLA.** Resolution SLA or Resolution Time SLA is the total time agreed between service provider and service consumer to fully resolve and fully restore the reported issue into its original state. It is sometimes refer to agreeable contracted delivery time of the service or performance. In short, resolution time is total time consumed on communication/coordination time and engineer on-site time until the ticket is resolved.
- **Communication/Coordination Time.** Communication/Coordination time is total time taken to coordinate/communicate all relative personnel (i.e. engineer, technical specialist etc.) and equipment (i.e. hardware, software etc.) until the arrival of engineer at client-site. This comprises of total effort of both helpdesk support staff and engineer in communicating and coordinating necessary information and equipment to attend to reported ticket at client site. This inclusive of engineer travelling time from the case company to client-site.
- **Engineer On-site time.** Engineer on-site time is the duration engineer(s) spent at client-site in resolving the logged ticket.
- In short, resolution time is total time consumed in communication/coordination time and engineer on-site time when it first logged until it is resolved. The components of resolution time are summarized in Figure 71.

Resolution Time = Communication/Coordination Time + Engineer On-site Time

Source: Case study analysis compilation

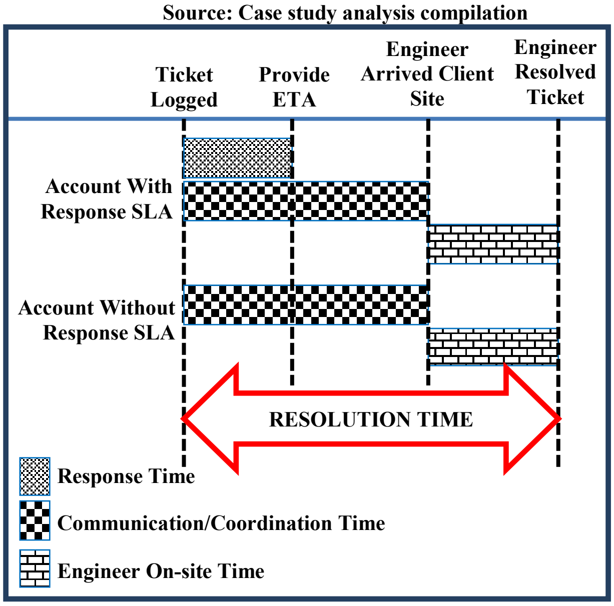


Figure 71 Company-C: Components of Resolution Time

7.2.3 Overview of Outsourcing Services

The case company offers a whole suite of business solutions from consultancy services to managed services, outsourcing services, infrastructure services and security services. Over the year, outsourcing services have created new avenues and opportunities for growth to Company-C. Outsourcing services are the main contributor to Company-C's annual avenue.

In business, outsourcing is about contracting out a business process to a third-party which sometime involves transferring employees and assets from one firm to another, but not always. Many companies outsource their business functions to Company-C because the outsourcing vendors can perform these outsourcing services more efficiently in term of time and cost. Effective outsourcing contracts can ensure the optimal performance of outsourcing and a win-win situation for both the outsourcing company and the vendor [255, 256]. Outsourcing is essentially a contractual relationship and contracts play an important role in outsourcing management. It is a common practice for companies to use a contract to specify the desired outsourcing business.

Majority of the contracted outsourcing services to Company-C spans nationwide within Malaysia. The rich pool of resources forms the backbone of Company-C service provision enables the case company itself to deploy competent and knowledgeable staff whenever possible. Today, outsourcing services has moved beyond knowledge-intensive services to include a plethora of other services closely allied with or supporting the company's core business [257].

A main contribution of the outsourcing services falls into the category of break-fixes and the components of break-fix are illustrated in Figure 72. **Break-fix** is an approach to dealing with technical support; when IT crises arise (i.e. something breaks or mal-function), someone (i.e. expert, specialist, professional etc.) fixes it. This is the most common approach taken by

Company-C in its outsourcing services. Break-fix is reacting to problems that have already occurred and Company-C is judged by how quickly they can attend to a problem and resolve the problem within agreeable SLA.

Source: Case study analysis compilation

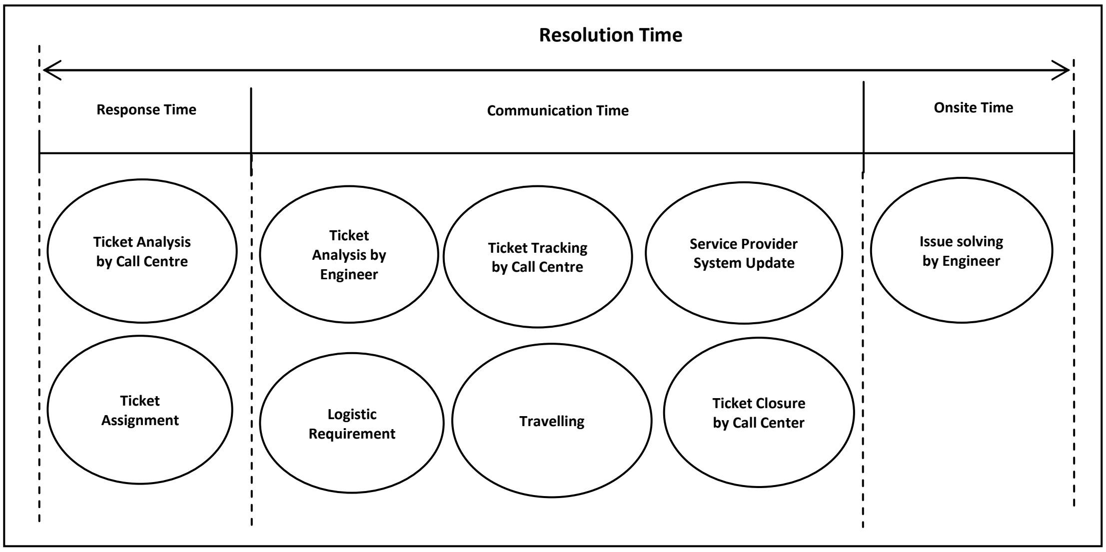


Figure 72 Company-C: Components of Break-Fix

The terms "Outsourcing Services" and "Service Level Agreement (SLA)" are closely related and needed to work hand-in-hand to reduce outsourcing risks. The author Huai outlined the importance of SLA in the outsourcing services industry: "SLA details the service level a company can expect from an outsourcing vendor and the consequences for failing to achieve them" [256]. In the context of outsourcing, effective SLAs are extremely important to ensure effective outsourcing engagements. From the company outsourcing service, SLA helps to define what they expect as a way of insuring that they get that service from outsourcing. In the perspective of outsourcing vendors, it prevents their customer from having unrealistic expectations.

7.2.4 Data Gathering

7.2.4.1 Interviews

Interview – with Executive Director

The first meeting with Mr. Tan was scheduled on 8th November 2012 and it kicked start with exploring the research opportunities using Company-C Outsource Services as the Six Sigma case study project. A summary of literature reviews about success stories of Six Sigma implementation in different business areas of IT Services, IT Processes and IT Products are shared with Mr. Tan; as well as a real successful IT case study of Six Sigma implementation the team underwent for the research project.

As discussed earlier, Company-C covers diverse areas of IT business intents with the main source of business revenue generated from the outsourcing services (i.e. maintenance and support services) by deploying a rich pool of technical support and helpdesk support personnel to many industry leader companies especially banking, government and private links companies. The team was briefed on the operational flow for all business intent. The overview picture of how various services cycle is carried out was shared to the research team to better understand the business content and business nature of Company-C. Thereafter, a series of meetings were scheduled to further explore the potential of Six Sigma case study in Company-C for process improvement.

Interview – with Operation Manager

A meeting with Ms. Wong was scheduled four months later on the 4th March 2013 after a thorough analysis of understanding operational activities workflow for various business intents of Company-C. Though Company-C provides a wide array of IT services, outsourcing services are provided through onsite troubleshooting and support, which is also known as on-site break-fix service, through contracting with principal vendor of maintenance and manufacturer.

Company-C is adopting ITIL in the area of "ITIL Service Strategy and IT Service Operation" informally for operational guidance on clarification and prioritization of service-provider investment in IT services. This aim of the quality improvement initiative is to detect, resolve and restore normal service operation as quickly as possible and minimize the adverse effect on business operation, thus ensuring the best possible levels of service quality and availability are maintained. Although Company-C has informally adopted a minor section of ITIL guidelines, the operation team still encountered non-conformances of SLA which jeopardize the effectiveness of resource utilization as well as team motivation and morale.

SLA plays an important role in providing guidance to the outsourcing management team to eliminate risks; and to bridge the gap between outsourcing service vendor and the end-users. Therefore, the role of the helpdesk team as the main coordinator between vendors and end-users are crucial to SLA achievement. Most importantly, the research team are being briefed on the overview picture of vendor-customer outsourcing business flow which provide further insight into the difficulties faced with end-users as well as vendors while performing outsourcing services.

Interview – with Helpdesk Supervisor

To gain a complete picture of the vendor-client outsourcing services, an interview was conducted with the helpdesk supervisor Ms. Nuril on 18th March 2013. This sharing session allowed a better understanding of the role of the helpdesk in assisting, managing and monitoring the daily outsourcing activities for variety IT needs, each with different SLAs from various vendor-client accounts. At the same time, the research team managed to interview two helpdesk support staff (Ms. Raja and Ms. Nisha) that required to be stationed at client-site on 17th June 2014.

Helpdesk is the medium of communication channel between vendors, pool of engineers and clients/end-users. In order to cope with increasing volume of outsourcing services with limited resources, it is necessary and important to establish a systematics, effective and efficient operational mechanism to attend and resolve all tickets in the shortest possible time frame to minimize operational cost. Hence, it is important to meet the agreeable SLAs with limited resources and to reduce work redundancy among the engineers.

Interviews - Lead Engineer

A face-to-face interview with the lead engineer En. Asnawi was carried out on 17th June. This allows a better understanding of the outsourcing services activities from the engineers' perspective. To better understand the management of engineers the research team witnessed few scenarios where conflict arises among engineers; as well as among engineers and helpdesk support personnel.

For those engineers away from Klang Valley, a series of scheduled phone interviews were arranged on 14th June 2013 to better understand engineers' assignment process. A total of six phone interviews covering the north, south, east, west and central region of Malaysia were carried out to ensure unbiased viewpoints are gathered across the regions.

7.2.4.2 On-The-Job-Observation

This learning process of On-The-Job-Observation aims to learn and observe vendor-client outsourcing services; from vendor to Company-C (via helpdesk center) to end-users (i.e. client). The daily activities which flow through observing the behavior of incumbents performing their daily routines enabled first-hand knowledge and information to be gathered about the vendor-client workflow so that the business activities can be analyzed for future improvements. To better understand the various stages of business activities and workflow involved in the vendor-client outsourcing services, a series of on-the-job observations were put in place as follows:

- Helpdesk center. A week long (10-14 Jun 2013) job observations were scheduled at the helpdesk center to observe and to study its role in bridging the gap between vendors and end-users in resolving IT services within the permissible SLA time constraint.
- For engineers within Klang valley, the researcher was stationed at the KL site to observe how the lead engineer manages, coordinates, assigns, delegates and guides the engineers' in dealing with vast volume of daily tickets from different vendors across different SLAs constraints.

After two weeks of feasibility study at the case company, the following observations were made:

- There are accounts delivered within the agreeable SLA but majority of the outsourcing services are resolved with violation of SLAs.

- The outsourcing services received by Company-C are more than the pool of engineers can manage. In short, there exists a scenario where outsourcing services are not in proportion with numbers of available engineers.
- The effectiveness and efficiency of communication between helpdesk support staff and engineers are crucial in meeting SLAs. Despite proper planning, SLA violation, cost overrun and rework/revisit are the common challenges the Company-C has been facing.
- The true root-cause to these challenges was unknown at the time of study; Mr. Tan would like to further understand the root-cause of these challenges which always deter the outsourcing team from meeting the agreeable SLAs.
- Since all the vendor-client accounts are running simultaneously over the years with the same pool of engineers, no significant effort has been taken to investigate the root-cause and hence no predetermined solution has been identified.

7.2.5 Identification of Core Processes, Support Processes and Key Customers

As discussed in the section 7.1.1, the **core processes** of Company-C can be categorized into Consultancy Services, Managed Services, Outsourcing Services, Infrastructure Services and Security Services. Among the standard processes that provide key resources or capabilities, **support processes** enable the core processes to perform.

Since the business nature of Company-C is heavily resource-driven, the support processes rely heavily on human resources (lead engineers, engineers, helpdesk support staff, IT Specialist, logistics staff, technical staff, supervisor etc.), hardware and software (i.e. internal or external), IT Infrastructure (i.e. WiFi, WiMax, Internet Access etc.), process (formal and informal), QA (formal and informal) as well as finance and strategies in supporting all the core processes.

Source: Case study analysis compilation

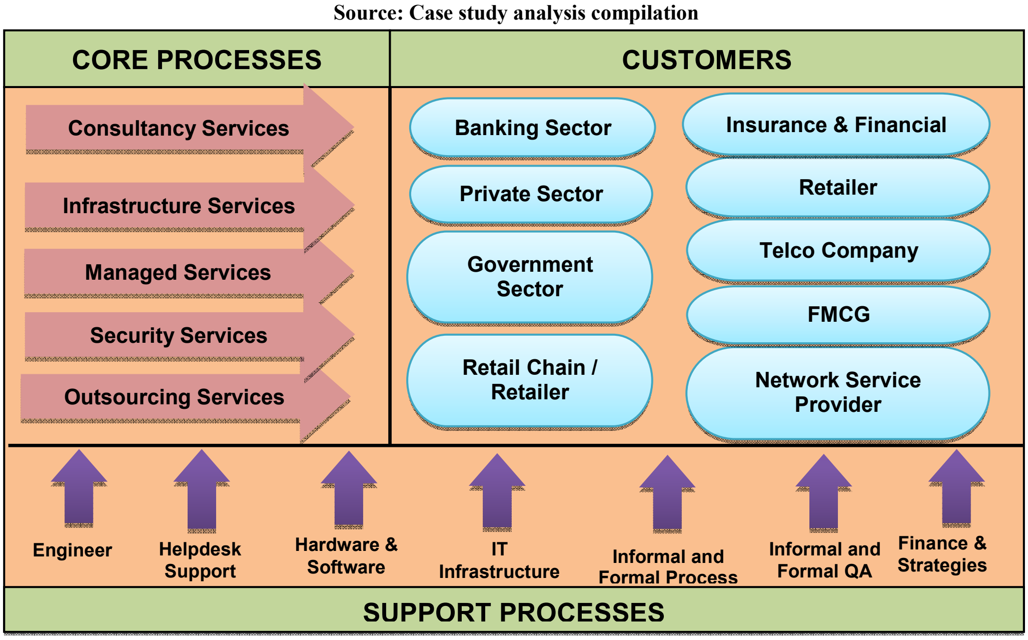


Figure 73 Company-C: Core Processes, Support Processes and Key Customers

It is important and necessary to identify the vendors and key customers of Company-C in order to develop appropriate messages and methods to engage them; to implement a plan to foster the business relationship and stay competent among others competitors. Ever since Company-C successfully secured projects from the banking industry, Company-C has aggressively expanded its IT business into various industries. Its key customers, ranging from the retailer/retailer chains to Telco companies, network service providers, insurance, financial and others which is yet to be disclosed. The overall high level identification and integration of the identified core processes, support processes and key customers of Company-C can be summarized into Figure 73.

7.2.6 Overview of Break-fix Process: SIPOC Diagram

SIPOC diagram displays a cross-functional set of activities in a single, simple diagram. It uses a framework applicable to processes of all sizes either for selected departmental process flow or for the entire organization. The SIPOC diagram for Company-C is defined in Figure 74, the next step is to define the CTQs characteristics [115] and issues, VOC, the potential improvement opportunities, and important quality measures and expectation [11, 36]. Company-C's projects are skewed towards "process and SLA conformance" as its CTQs.

Source: Case study analysis compilation

Supplier	Input	Process	Output	Customer	Requirements
Printer	IT knowledge -based resources	Vendor reported a break-fix via email	Signed Job Sheet	Vendor Support Personnel	SLA Time frame
Hardware vendor	Project Schedule	Ticket assignment to engineer	Ticket Closure	Departmental Head / Manager	Agreed SLA Contract
Software vendor	SLA Contract	Engineer perform on-site diagnostic	Ticket Resolved Within SLA	IT / Operation Manager	On Time SLA Resolution
Internet Service Provider	Software	Ticket closure (Helpdesk Support)	IT Support	Client / End-users	Job Sheet
Telco Companies	Hardware	Ticket closure (Vendor site)	SLA Report	IT and non-IT SMEs	Fulfilling and Resolving IT issues
Network Infrastructure Supplier	Ticket Details	SLA Report	Resolution Report	Vendors	Ticket Details (email)

Figure 74 Company-C: Break-Fix SIPOC Diagram

7.2.7 Identification of Critical-To-Quality and Voice-Of-Customer

In the Six Sigma process, improvements will make sense only if CTQs are directly related to the requirements for customer satisfaction. Table 88 is the CTQs of the case company, as part of definition outcome from the Define phase:

Table 88 Company-C: CTQs

No	Defections	CTQs
1.	SLA resolution defection	Discrepancies between actual resolution time and agreeable resolution SLA
2.	SLA response defection	Discrepancies between actual response time and agreeable response SLA
3.	SLA resolution / response expire computation defection	Discrepancies of computed expire resolution/response SLA and agreeable resolution/response SLA
4.	Engineer on-site defection	Discrepancies between actual engineer on-site time and benchmark engineer on-site time
5.	Resource utilization	• Resource utilization in all regions within the available pool of engineers • Maximizing number of tickets per engineer per day

Source: Case study analysis compilation

According to Pande et al., [152], the CTQs measures can be posted and grouped into two broad categories of: (i) Output and (ii) Input/Process as summarized in Table 89:

Table 89 Company-C CTQs Measure

No		Output Measures	Input/Process Measures
1.	Resolution SLA Defect	Quantity/Percentage of reported tickets violate agreed resolution SLA by severity level	Discrepancies between actual resolution time and agreed resolution SLA
2.	Response SLA Defects	Quantity/Percentage of reported tickets violate agreed response SLA by severity level	Discrepancies between actual response time and agreed response SLA
3.	Resolution / Response SLA expire Computation Defects	Quantity/Percentage of reported tickets with different SLA from vendor	Discrepancies of internal computed resolution/response SLA against vendor's SLA
4.	Engineer On-site Duration Defects	Efficiency and effectiveness of engineer on-site diagnosis duration	Average time taken for an engineer to perform an on-site diagnosis
5.	Resource Utilization Defects	Efficiency and effectiveness of engineer ticket allocation per day/month	Percentage utilization of engineer per day/month

Source: Case study analysis compilation

Once the CTQs have been identified, the underlying reasons for customer dissatisfaction and defection are sought. For example, by identifying the chief contributors of the root-cause (i.e. ineffective/inefficient of ticket assignment, lack of skill set and expertise in ticket resolution, lack of consistency and accuracy in SLA expire computation etc.), the case company is facing an increase of repetitive effort (i.e. on-site revisit, overlapping effort in ticket tracking and follow-up, ticket closure etc.) and violation of SLAs performance.

7.3 Measure Phase

7.3.1 Introduction

As discussed earlier, the case company is an IT company that offers a whole suite of business solutions to its customers. Service quality has been the main concern from the case company VOC as well as from the vendor team. Service quality has always been a difficult topic to define [217], as well as SLA conformance has always been exceptionally difficult. The aim is to ensure daily operational activities minimizes outsourcing risks (i.e. SLA violations) and maximizes engineers' performance (i.e. on-site duration, number of attended tickets per engineer per day) in return of optimization in operation cost.

SLAs are formalized contracts between service providers and service consumers. SLAs usually specifies the agreed-upon level of availability, serviceability, performance and operation of services in measureable terms what services the service provider will furnish and what penalties will be incurred if the service provider violates the established goals [258, 259]. The violation of an SLA by the service provider typically results in a penalty to compensate the service consumer [258]. In order to avoid such situations, the service provider needs to recognize critical service instances and to take appropriate counter measures before a violation happens. Therefore a measurement for quantifying the danger of SLA violation is needed to remedy the occurrences of such situation. One potential remedy is to monitor SLA violations with strategy like provisioning of additional resources.

The two main processes of measuring current performance are “Plan and execute measures of actual SLA performance against contractual SLA requirement” and “Develop baseline defect measures and identify improvement opportunities”. Table 90 depicts the five-step measurement implementation model suggested by Pande at al., [152] which gives an overview of key questions/actions that would need to be asked at each of the measurement steps. The research team is deploying this model to the “Outsourcing Services – Break-Fixes” project:

Table 90 Company-C: 5-Steps Measurement Implementation Model

Step	Question and Answer
Select What To Measure	Q: What output or service requirement(s) will best help the case company gauge performance to customer needs? A: Conformance of Resolution SLAs and Response SLAs
Develop Operational Definitions	Q: How can the research team clearly describe the factor we are trying to track or count? A: By in-depth understanding the key performance indicators and key process characteristics contribute to SLAs violation
Identify Data Sources(s)	Q: Where can the research team find or observe data to provide the measure? A: Manually from historical data (internal SLA tracking records), engineer performance and engineer utilization.
Prepare Collection & Sampling Plan	Q: What forms or tools are needed to capture and organize data? A: Job Sheet, Manual SLA Tracking File, Emails, Forms (i.e. hardware and software replacement checklist, data sheets etc.), Stratification and Sampling Q: How many observations or items need to be counted to get an accurate measure? A: As many as possible
Implement & Refine Measurement	Q: Can the team test our measures before going into full-fledged implementation? A: Yes. Q: How should the monitoring of data gathering be carried out? A: By on-the-job observation, tracking and controlling of project plan between “baseline” and “actual” outcome.

Source: Case study analysis compilation

7.3.2 Data Collection

A total of five project accounts from various categories of business intent were taken into consideration in the Six Sigma Measure phase based on data measurements of CTQs defined in the Define phase. Since the case study company experienced non-consistent SLAs violation and weak utilization of engineers across the main region for most project accounts, much time was spent retrieving documents, forms, job sheets, checklists and various possible historical sources and archives for data analysis. After much effort and time spent on these data sources, the research team summarized the operational definitions of CTQs findings for the five project accounts in Table 91 and respective project variables for the five project accounts are tabulated in Table 92.

As discussed, resolution time is the sum of communication/coordination time and engineer on-site time. Since all project accounts showed significant achievement in Response SLA, the main key performance indicators to Resolution SLA would be the factor of “Communication/Coordination Time” and “Engineer On-site Time”. To facilitate the effectiveness and efficiency of total time taken for communication/coordination, total SLAs resolution time, SLAs response time and communication/coordination time are segmented into four quadrants, i.e. Top 1st, Top 2nd, Bottom 2nd and Bottom 1st. For example, if the contractual resolution SLA is 6 hours, The first 25% of the resolution time (0 hour – 1.5 hour) falls into Top 1st quadrant, the second 25% (1.5 hour – 3.0 hour) falls into Top 2nd quadrant, the third 25% (3.0 hour – 4.5 hour) falls into Bottom 2nd quadrant and last but not least the last 25% (4.5 hour – 6.0 hour) falls into Bottom 1st quadrant. Therefore, an ideal graph distribution would be an exponential graph which shrinks quickly with “Period Time” being the x-axis and “Percentage of Attended Tickets” on the y-axis as shown in Figure 75. The ideal situation would be more tickets (at least 60-80%) are attended, resolved and communicated/coordinated within the first 50% of the measurement metric time leaving minority of total tickets towards the last quadrant of the measurement metric time. Outliar are the resolution/response time which exceeded the agreed SLA boundary (i.e. more than 6.0 hours).

Source: Case study analysis compilation

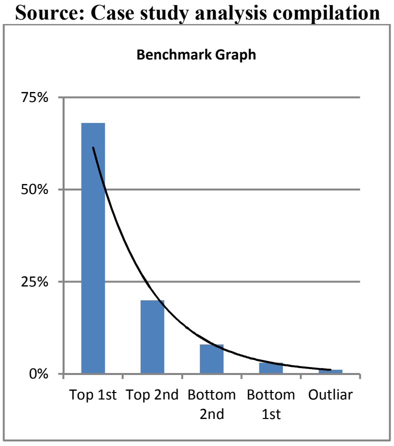


Figure 75 Company-C: Benchmark Graph

Table 91 Company-C: Operational Definition for Main Account Projects

<table>
<tr><th>Projects / Operational Definition</th><th>Account-1 (Retailer)
November 2012</th><th>Account-2 (Bank-C)
June 2013</th><th>Account-3 (Bank-R)
June 2013</th><th>Account-4 (Government)
June 2013</th><th>Account-5 (Bank-M)
April 2013</th></tr>
<tr><td>Total Revenue Contribution</td><td>12%</td><td>10%</td><td>10%</td><td>8%</td><td>5%</td></tr>
<tr><td>Total Tickets</td><td>304</td><td>554</td><td>718</td><td>93</td><td>168</td></tr>
<tr><td>Resolution SLA</td><td>• Exceed SLA (8 , 3%)
• Within SLA (297 , 97%)</td><td>• Exceed SLA (326 , 59%)
• Within SLA (228 , 41%)</td><td>• Exceed SLA (110 , 15%)
• Within SLA (608 , 85%)</td><td>• Exceed SLA (13 , 14%)
• Within SLA (80 , 86%)</td><td>• Exceed SLA (7 , 4%)
• Within SLA (161 , 96%)</td></tr>
<tr><td>Response SLA</td><td>• Exceed SLA (7 , 2%)
• Within SLA (297 , 98%)</td><td>N/A</td><td>N/A</td><td>N/A</td><td>• Exceed SLA (2 , 1%)
• Within SLA (166 , 99%)</td></tr>
<tr><td>Resolution SLA Performance</td><td>• Top 1st (123 , 41%)
• Top 2nd (83 , 27%)
• Bottom 2nd (43 , 14%)
• Bottom 1st (47 , 15%)
• Outliar (8 , 3%)</td><td>• Top 1st (39 , 8%)
• Top 2nd (35 , 7%)
• Bottom 2nd (40 , 8%)
• Bottom 1st (65 , 13%)
• Outliar (313 , 64%)</td><td>• Top 1st (397 , 58%)
• Top 2nd (186 , 27%)
• Bottom 2nd (66 , 10%)
• Bottom 1st (33 , 5%)
• Outliar (8 , 1%)</td><td>• Top 1st (42 , 52%)
• Top 2nd (14 , 17%)
• Bottom 2nd (10 , 12%)
• Bottom 1st (4 , 5%)
• Outliar (11 , 14%)</td><td>• Top 1st (46 , 28%)
• Top 2nd (83 , 50%)
• Bottom 2nd (5 , 3%)
• Bottom 1st (0 , 0%)
• Outliar (33 , 20%)</td></tr>
<tr><td>Response SLA Performance</td><td>• Top 1st (253 , 73%)
• Top 2nd (28 , 9%)
• Bottom 2nd (11 , 4%)
• Bottom 1st (5 , 2%)
• Outliar (7 , 2%)</td><td>• Top 1st (0 , 0%)
• Top 2nd (0 , 0%)
• Bottom 2nd (0 , 0%)
• Bottom 1st (0 , 0%)
• Outliar (0 , 0%)</td><td>• Top 1st (0 , 0%)
• Top 2nd (0 , 0%)
• Bottom 2nd (0 , 0%)
• Bottom 1st (0 , 0%)
• Outliar (0 , 0%)</td><td>• Top 1st (0 , 0%)
• Top 2nd (0 , 0%)
• Bottom 2nd (0 , 0%)
• Bottom 1st (0 , 0%)
• Outliar (0 , 0%)</td><td>• Top 1st (164 , 83%)
• Top 2nd (0 , 9%)
• Bottom 2nd (1 , 4%)
• Bottom 1st (1 , 2%)
• Outliar (3 , 2%)</td></tr>
<tr><td>Coordination / Communication Performance</td><td>• Top 1st (111 , 37%)
• Top 2nd (83 , 27%)
• Bottom 2nd (43 , 14%)
• Bottom 1st (47 , 15%)
• Outliar (20 , 7%)</td><td>• Top 1st (50 , 9%)
• Top 2nd (54 , 10%)
• Bottom 2nd (73 , 13%)
• Bottom 1st (65 , 12%)
• Outliar (312 , 56%)</td><td>• Top 1st (100 , 21%)
• Top 2nd (81 , 17%)
• Bottom 2nd (88 ,19%)
• Bottom 1st (63 , 13%)
• Outliar (141 , 30%)</td><td>• Top 1st (35 , 42%)
• Top 2nd (20 , 24%)
• Bottom 2nd (6 , 7%)
• Bottom 1st (6 , 7%)
• Outliar (17 , 20%)</td><td>• Top 1st (46 , 28%)
• Top 2nd (83 , 50%)
• Bottom 2nd (5 , 3%)
• Bottom 1st (0 , 0%)
• Outliar (33 , 20%)</td></tr>
<tr><td>Resolution SLA Discrepancy Computation</td><td>• X Computation (0%)
• √ Computation (100%)</td><td>• X Computation (46%)
• √ Computation (54%)</td><td>N/A</td><td>N/A</td><td>• X Computation (0%)
• √ Computation (100%)</td></tr>
<tr><td>Contractual Response and Resolution SLA</td><td><table><tr><th>Severity</th><th>Response SLA</th><th>Resolution SLA</th></tr><tr><td>S1</td><td>1 hr</td><td>14 hr</td></tr><tr><td>S2</td><td>1.5 hr</td><td>18 hr</td></tr><tr><td>S3</td><td>2 hr</td><td>42 hr</td></tr><tr><td>S4</td><td>4 hr</td><td>63 hr</td></tr></table></td><td>• Response and Resolution SLA – Response and Resolve Within 4 working hours
• IMAC – response and resolve within 3 working days</td><td><table><tr><th colspan="3">Working Hr/Day</th></tr><tr><th>Type</th><th>Response SLA</th><th>Resolution SLA</th></tr><tr><td>P1</td><td>1.5 hr</td><td>3 hr</td></tr><tr><td>P2</td><td>4 hr</td><td>6 hr</td></tr><tr><td>IMAC</td><td colspan="2">3 days</td></tr></table></td><td>• Response and Resolution within 1 working day
• If > 1 day, provide ETA</td><td><table><tr><th>Zone</th><th>Response SLA</th><th>Resolution SLA</th></tr><tr><td>1</td><td>2 hr</td><td>4 hr</td></tr><tr><td>2</td><td>3 hr</td><td>5 hr</td></tr><tr><td>3</td><td>4 hr</td><td>6 hr</td></tr><tr><td>4</td><td>6 hr</td><td>8 hr</td></tr><tr><td>5</td><td>NBD</td><td>NBD</td></tr><tr><td>6</td><td>NBD</td><td>NBD</td></tr><tr><td>7</td><td>NBD</td><td>NBD</td></tr><tr><td>B1</td><td>NBD</td><td>NBD</td></tr><tr><td>B2</td><td>NBD</td><td>NBD</td></tr></table></td></tr>
</table>

Source: Case study analysis compilation

Table 92 Company-C: Summary of Variables by Project

Project Variables	Account-1 (Retailer) Nov 2012	Account-2 (Bank-C) Jun 2013	Account-3 (Bank-R) Jun 2013	Account-4 (Government) Jun 2013	Account-5 (Bank-M) Apr 2013
Resolution SLA Violation	3%	59%	15%	14%	4%
Response SLA Violation	2%	N/A	N/A	N/A	1%
Average Response Time (hr)	0.51	N/A	N/A	N/A	0.2
Average Coordination / Communication Time (hr)	15.97	7.5	9.49	15.19	5.41
Average Engineer On-site Time (hr)	2.85	1.63	1.31	1.03	0.25

Source: Case study analysis compilation

7.3.3 Summary of Overall Data Collection

In view of the overall project performance for Account 1 to 5, the key project performance for CTQs is summarized below:

- **Resolution SLA and Response SLA** (Figure 76, Figure 77, Figure 78 and Figure 79) – Account-1 and Account-5 were the two main accounts that conformed to 95% of Resolution SLA and Response SLA. Account-1 demonstrated an achievement of 97% and 98% conformance in resolution SLA and response SLA respectively whereas Account-5 was reported with 96% and 99% in those SLA performances respectively. The SLA performance for Account-3 and Account-4 were satisfactory and is meeting 85% and 86% respectively for resolution SLA. However, Account-2 was reported to have large under-performance with 326 tickets (59%) out of 554 tickets violating the resolution SLA, leaving only 41% of the tickets meeting the agreeable SLA. In general, there is no issue with response SLA performance but much effort is needed for resolution SLA improvements.
- **Response Time, Communication/Coordination Time and Engineer On-site Time**. The performance of Communication/Coordination time for the five project accounts can be observed from Figure 80 using Figure 75 as a benchmark graph. Account-1 showed a medium shrink exponential graph with average coordination/communication time of 15.97 hours and an average of engineer on-site time of 2.85 hour. Most importantly, Account-1 only reported with 3% violation of resolution SLA. Although Account 3, 4 and 5 do not produce a consistent shrink of exponential graph for communication/coordination time, the resolution performance is at satisfactory level. However, Account-2 was observed with an exponential graph which grows quickly as communication/coordination time passes. This conclude that most tickets were communicated/coordinated towards the end of the resolution time frame with little time buffer left for resolution and put the ticket at risk in meeting the SLA (Figure 80).

Source: Case study analysis compilation

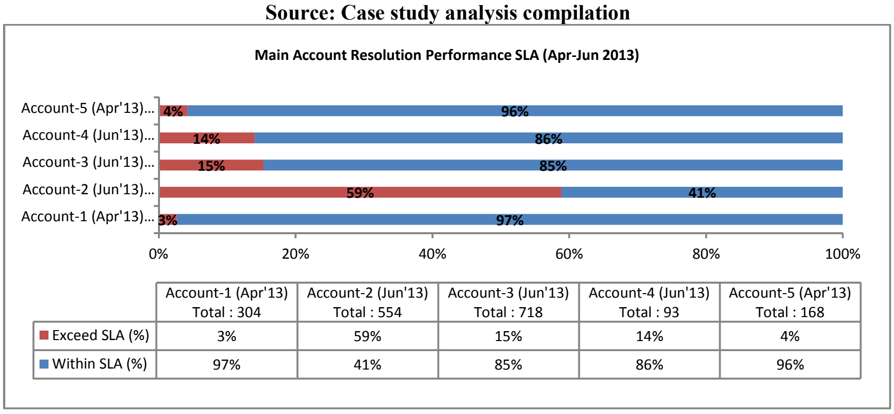


Figure 76 Company-C: Main Account SLAs Resolution Performance

Source: Case study analysis compilation

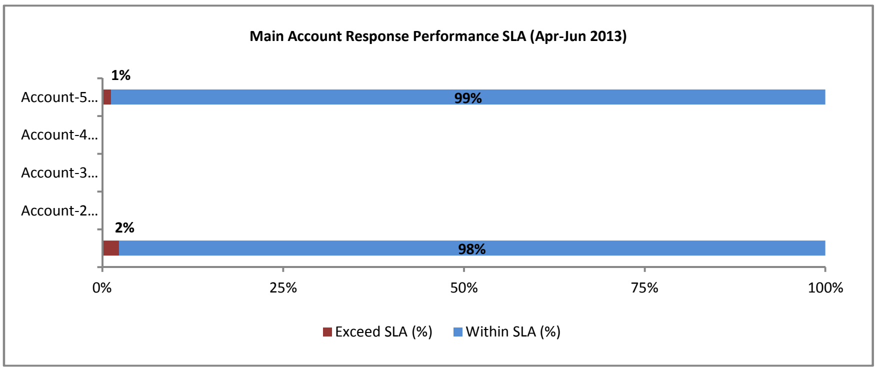


Figure 77 company-C: Main Account SLA Response Performance

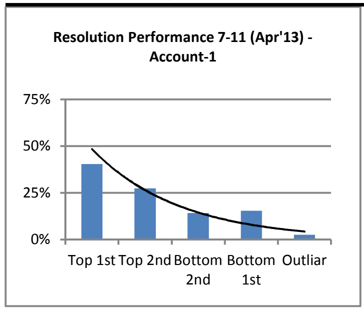
7.3.4 Six Sigma Project Selection

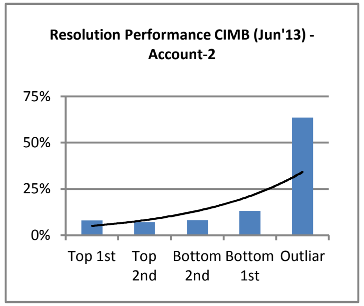
It is important to strike a balance between the broad criteria of "Meaningful" and "Manageable" in selecting and justifying the appropriate project account for the Six Sigma project. In view of the overall data findings for all the five project accounts, although Account-3 and Account-4 does not meet the contractual SLA of 95% conformance, respective performance of 85% and 86% in resolution conformance can be improved independently by the internal-team-driven focusing on resource allocation.

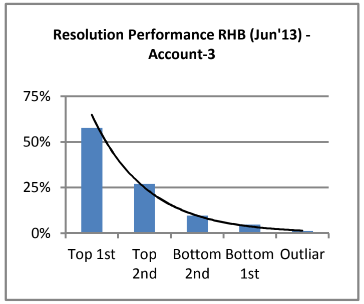
Account-2 is the second biggest account with revenue contribution of 10% annually. Findings revealed that Account-2 is underperforming in resolution performance with 59% of total tickets for the month of June 2013 violated the resolution SLA. With the aid of outcomes from these findings, the research team concluded that Account-2 requires urgent efforts in managing the resources more effectively and efficiently for SLA performance improvements; for competitive position as well as market strength for both short-term and long-term financial gains. The findings which the research team gathered from detailed feasibility study; from various supportive team of engineers (on-site and off-site), helpdesk support (on-site and off-site), logistics staff and the management team helped to justify the potential of Account-2 for the current Six Sigma case study project (as discussed by Pande et al., [152]):

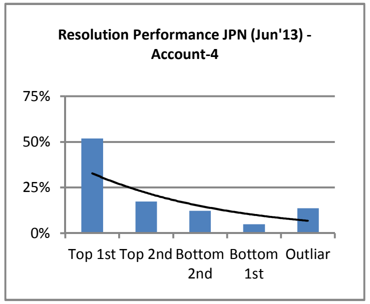
- There exists a gap between planned and actual performance such as SLA achievement, engineers' utilization, resolution time, engineer on-site time etc.
- The cause of the challenges were not clearly understood
- There is no obvious solution and there isn't any predetermined solution at the moment

Resolution SLA Performance









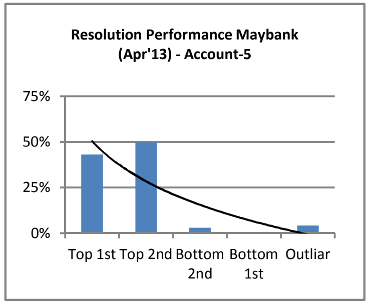
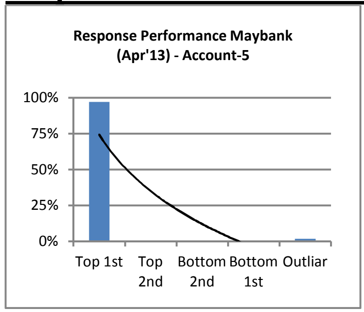


Figure 78 Company-C: Main Account Resolution SLA

Response SLA Performance



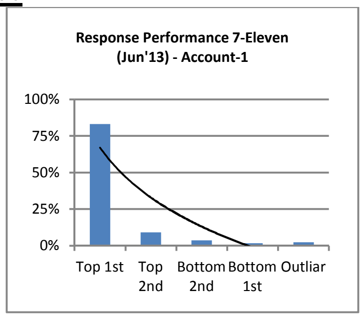
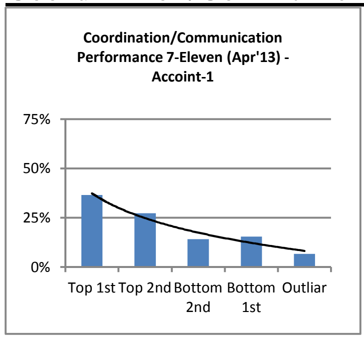
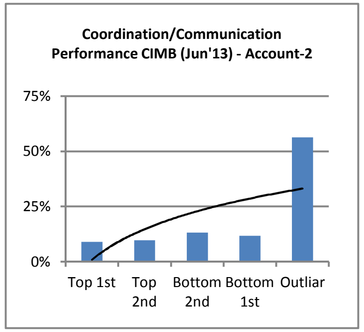
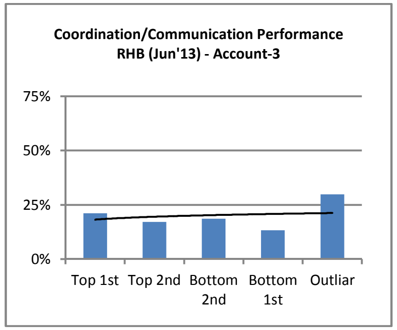


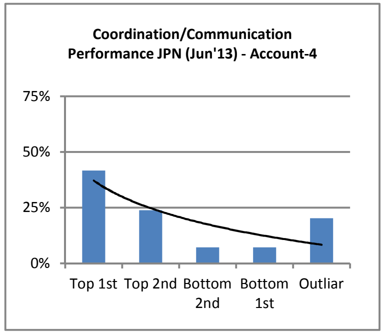
Figure 79 Company-C: Main Account Response SLA Performance

Coordination/Communication Performance









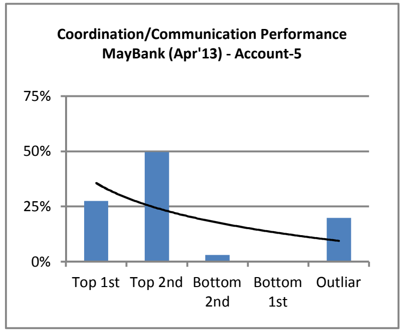


Figure 80 Company-C: Main Account Communication/Coordination Performance

7.3.5 Project Account-2

7.3.5.1 Introduction

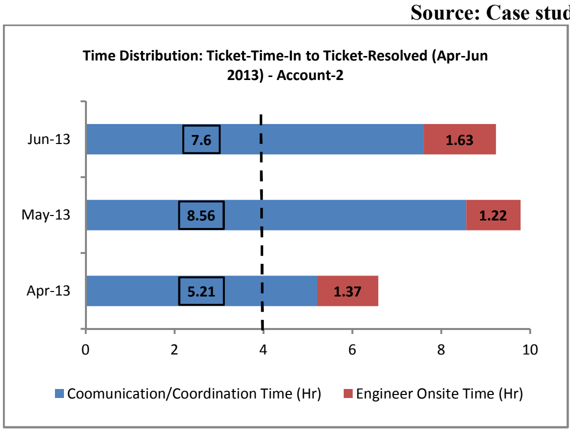
Project Account-2 is a nationwide project covering east and west Malaysia. The case company provides professional services such as consultancy, outsourcing services etc. to its customers. Project Account-2 was first started in Jan 2013 with a total tickets volume of 300-400 across all regions in Malaysia. In the first 6 months, the demand for IT services increased to 500-650 tickets due to new project launches. Due to the drastic and unexpected increase of ticket volume for Account-2, much ad-hoc decisions-making was needed to cope with the drastic increase in demand for break-fixes activities. As such, this directly impacted engineers from the same pool of resources being utilized among other project accounts for the case company.

The contractual SLA for "Incident" cases is to respond and resolve within 4 working hours; whereas for "IMAC" cases is 3 working days. The IMAC cases consists of any cases related to "software **I**nstallation", "**M**ovement of hardware", "**A**dditional hardware (e.g. RAM, hardisk etc.)" and "**C**hange of hardware".

7.3.5.2 Project Problem Statement

In order to better utilize its' available scarce resources, the same pool of well-trained engineers within the same region are shared among all the project accounts of the case company. Since each project account differs in business nature, its **contractual SLAs are considerably differing across different accounts**. Account-2 is tightly constraint to 4 working hours in responding and resolving a ticket, the observed average time taken to communication/coordination a ticket is 7.5 hours. As a result (Figure 81), more than 50% of total tickets (i.e. 59%) for June 2013 violated the resolution SLA. The duration of 4.0 working hour resolution SLAs is inclusive of 1.63 hours of engineer on-site time, this implies that any tickets observed exceeding 2.37 hours of communication/coordination time will result in SLA violation. As a result, the duration span of communication/coordination for a ticket is crucial and significant to SLA achievement.

Source: Case study analysis compilation



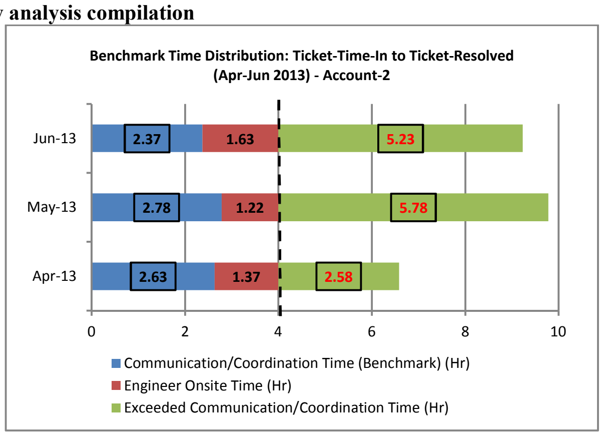


Figure 81 Account-2: Time Distribution (Actual vs Benchmark)

In summary, the overall resolution performance is the key characteristic for case company and both the communication/coordination time and engineer on-site time are the key performance indicators affecting the resolution performance. It is important to explore other potential key characteristics affecting the resolution performance of Account-2.

7.3.5.3 Findings

In response to the urgent needs of improvement in resolution SLA for Account-2, the research team conducted an in-depth analysis for the month of April'13, May'13 and June'13. The tabulated results for these three months will be benchmarked for suggestions of improvements in the Six Sigma project.

7.3.5.3.1 Account-2: Resolution SLA Defects

Source: Case study analysis compilation

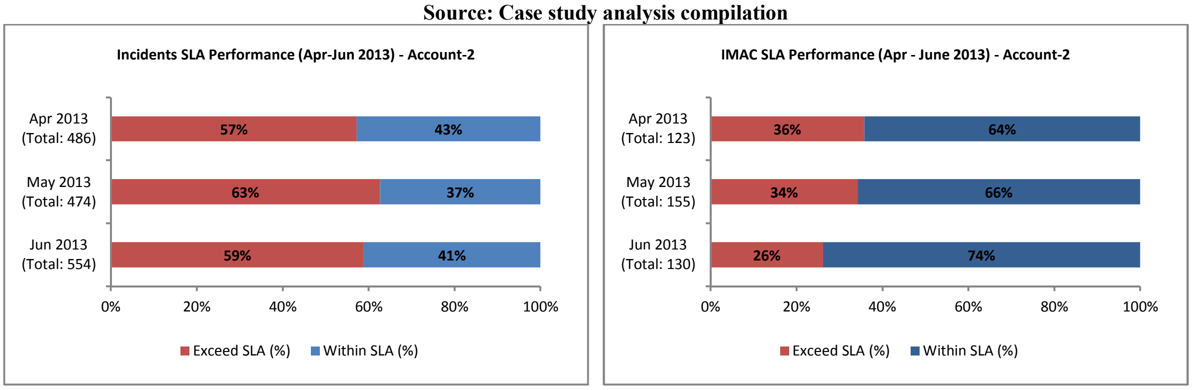


Figure 82 Account-2: Resolution Incidents SLA Performance and IMAC SLA Performance (Apr-Jun 2013)

Source: Case study analysis compilation

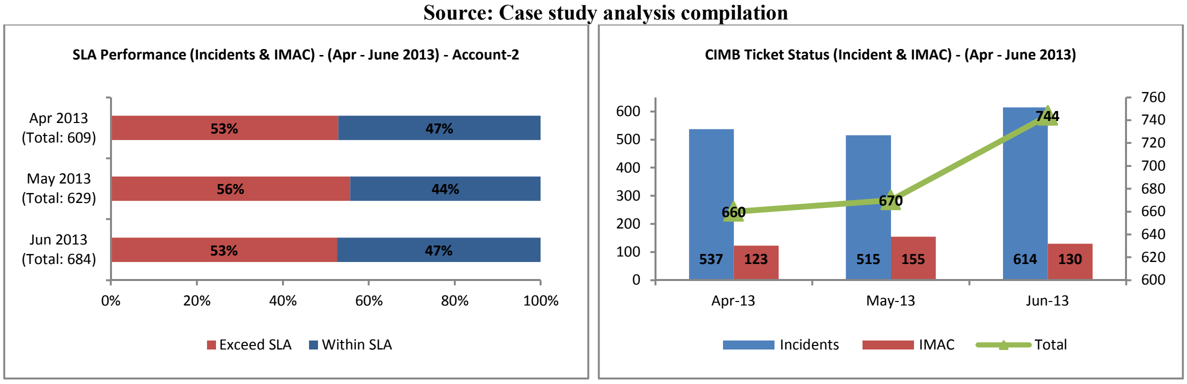


Figure 83 Account-2: Resolution SLA Performance (Incidents & IMAC) (Apr-Jun 2013)

Figure 82 and Figure 83 showed the SLAs performance for Account-2 in the month of April, May and June of 2013. For three consecutive months, both incidents and IMAC tickets violated the agreeable resolution SLAs achievement of 95%. Hence, the overall resolution performance is unsatisfactory. The reported SLAs violation in the month of April, May and June were 53%, 56% and 53% respectively in both tickets category. However, the SLAs violation from incident category (needed to be resolved within 4 working hours) required much attention as compare to IMAC tickets where resolution SLA is within 3 working days.

7.3.5.3.2 Account-2: Resolution SLA and Respond SLA Expire Computation Defect

Source: Case study analysis compilation

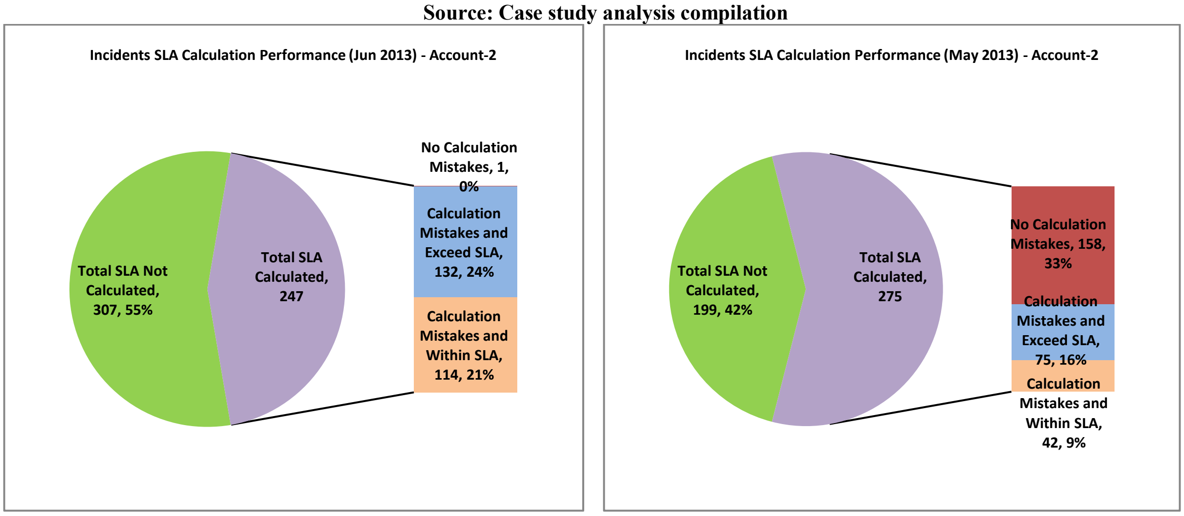


Figure 84 Account-2: Incidents SLA Calculation Performance (Jun 2013 and May 2013)

It was observed that there is a tendency of helpdesk support staff not calculating the SLA expire time for resolution SLAs (Figure 84). In the month of April, none of the tickets have resolution expire time calculated. Whereas in the month of May and June, almost half of the total tickets (i.e. 55% in June and 42% in May) are captured without resolution time expire being calculated. Despite a high reported percentage of tickets without SLA expire are captured, it was observed that 42% and 21% of tickets with wrong SLA expire time calculated (in the month of May and June respectively) still being resolved within the desire SLAs. This shows that there is a possibility of other factor(s) besides accuracy of SLA calculation is affecting the resolution performance.

7.3.5.3.3 Account-2: Communication/Coordination Time Defects and Engineer On-Site Defects (Incidents)

It can be observed from Figure 81 that the average duration of engineer on-site time from April to June is around 1.5 hour (i.e. average = 1.41 hour). This implies that the total communication/coordination time left to resolve the ticket is 2.5 hours (i.e. 4 hour – 1.5 hour). However, the communication/coordination time captured for the month of June, May and April are 7.6 hour, 8.56 hour and 5.21 hour respectively; which is by itself already exceeds the contractual resolution time of within 4.0 working hours (i.e. exceeded 5.23 hour, 5.78 hour and 2.58 hours respectively for Jun, May and April). This implied that the main root cause of resolution violation is greatly dependent on total time taken to communicate/coordinate the ticket among engineers.

Since the historical data showed a consistent average engineer on-site time of 1.5 hours, the proposed benchmark of communication/coordination should be 2.5 hours. At any case when any ticket required more than 2.5 hours for communication/coordination, there is a high risk that the ticket will violate the SLA. In summary, the shorter time taken to communicate/coordinate the ticket, the better chance for the ticket to be resolved within the agreeable SLA.

7.3.5.3.4 Account-2: Total Tickets Analysis by Major Region

The high level analysis on resolution SLA, communication/coordination time and engineer on-site time were carried out for the months of April, May and June; revealed high percentage of violation in resolution SLA. Hence, a more in-depth investigation is needed to ease of root-cause analysis for SLA performance improvements.

For the forthcoming investigation strategy, the research team decided to **streamline the analysis on major sites instead of crossed nationwide**. In order to achieve a more “manageable” scope in the Six Sigma project, the operation manager has shortlisted the following eight major sites as the basis for investigation: Kuala Lumpur, Ipoh, Johor Bahru, Penang, Kuching, Kota Kinabalu, Malacca and Seremban. Table 94 outlined a detailed analysis of the eight major regions for the month of April, May and June; the examined criteria are:

- Total tickets attended by each site
- SLA performance by each site
- Average received ticket per day by each site
- Average Communication/Coordination Time by each site
- Average Engineer On-site time by each site
- Average Resolution time by each site
- Average Exceeded resolution time by each site

It can be observed from Table 94 and Figure 85 that the top three major sites with most reported tickets are KL, Ipoh and Johor Bahru. KL constituted about 50% of total tickets for every month, with a reported resolution violation of 48%, 29% and 28% for June, May and April. However, comparatively against of total tickets within these three sites, KL has the shortest time duration in ticket communication/coordination (i.e. 6.52 hour as compare to 15.76 hour for Ipoh in the month of June) and hence its resolution time out-performed the other two sites (i.e. 7.84 hour as oppose to 17.71 hour for Ipoh in the month of June).

Since the majority of tickets originate from KL, any improvements implemented in KL site will constitute significant improvements to overall resolution SLA performance. Furthermore, Ipoh, Johor Bahru, Penang, Kuching and Kota Kinabalu faced the geographical disadvantage issue. The ratio between quantities of engineers, distance to client site and total ticket are significant; total travelling time by engineer from the reporting station to client site are excessive and hence less ticket can be attended. Therefore, collective effort should be focused to improve resolution time in KL as it has a high density of 230 service centers in geographical coverage area serving

51.17% total tickets in the month of May; as compare to 32 service centers with reported 7.6% total tickets in Ipoh.

Source: Case study analysis compilation

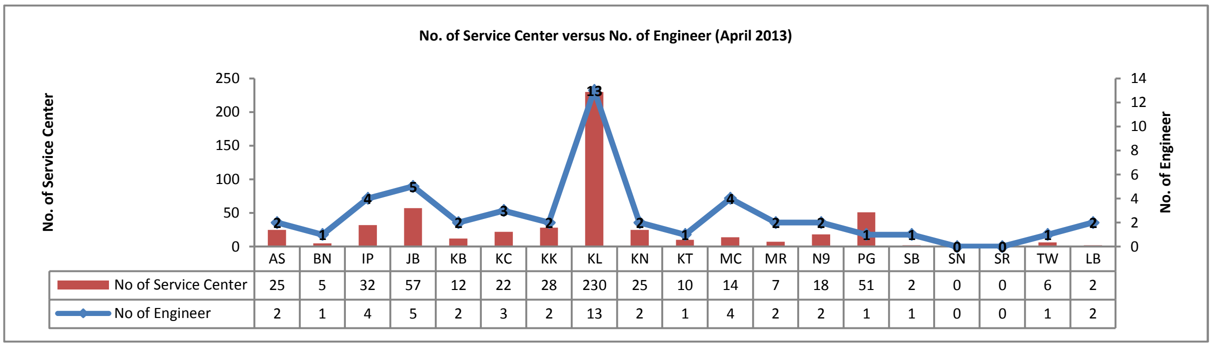


Figure 85 Company-C: No. of Service Center vs No. of Engineer (April 2013)

7.3.5.3.5 Account-2: Ratio Calculation Engineer-To-Tickets-By-Region

In view of respective regions handling different tickets volume, a detailed ratio analysis taking into consideration of ticket handled per engineer for the month of April, May and June are tabulated in Table 93. The ratio of Engineer-To-Ticket-By-Region revealed that KL which constituted 50% of total tickets were reported with a high ratio of 1:51, 1:24 and 1:23 respectively in the month of June, May and April. In the month of June, five engineers were assigned to Account-2 to attend 253 tickets; 11 engineers attended 262 tickets in May and 13 engineers attended 292 tickets in April. Since KL constitutes majority of tickets for Account-2 and the ratio of engineer-to-ticket-by-region for KL region is relatively much higher than other region, immediate attention and effort is needed to analyze root-cause(s) contributing to SLAs violation.

Table 93 Account-2: Engineer-To-Tickets-By-Region Ratio Analysis

Month	June 2013				May 2013				April 2013		
Region	Tickets by Region	No of FTE	Ratio		Tickets by Region	No of FTE	Ratio		Tickets by Region	No of FTE	Ratio
IP	66	5	1 : 13.5		39	6	1 : 6.5		15	4	1 : 3.75
JB	46	6	1 : 7.6		33	6	1 : 5.5		43	5	1 : 8.6
KC	26	4	1 : 6.5		13	2	1 : 6.5		12	3	1 : 4
KK	26	3	1 : 8.6		14	3	1 : 4.6		17	2	1 : 8.5
KL	253	5	1 : 50.6		262	11	1 : 23.8		292	13	1 : 22.46
N9	20	1	1 : 20		27	1	1 : 27		20	2	1 : 10
PG	40	1	1 : 40		30	3	1 : 10		40	1	1 : 40

Source: Case study analysis compilation

Table 94 Company-C: SLA Performance by Major Region

Bank-C- SLA Performance By Major Region - June 2013 (Total: 614)

Site	Total Ticket (%)	Total Ticket	N/A	Exceed SLA By Site	Within SLA By Site	By Region		All Region		Average Ticket Per Day (20 days)	Communication Time Per Ticket (Hr)	Eng On-Site Per Ticket (Hr)	Resolution Time Per Ticket (Hr)	Resolution Time Per Ticket	Exceed Resolution SLA By…hr	FTE Benchmark (2.5 Ticket Per Engineer Per Day)
						Exceed SLA By Site (%)	Within SLA By Site (%)	Exceed SLA By Site (%)	Within SLA By Site (%)							
KL	40.55%	249	20	114	115	50%	50%	20%	19%	12.5	6.52	1.32	7.84	7.84	3.84	4.98
IP	10.75%	66	5	50	11	82%	18%	8%	11%	3.3	15.76	1.95	17.71	17.71	13.71	1.32
JB	7.49%	46	7	32	7	82%	18%	5%	1%	2.3	14.44	1.83	16.28	16.28	12.28	0.92
PG	6.51%	40	2	18	20	47%	53%	3%	3%	2.0	4.36	2.12	6.48	6.48	2.48	0.8
KC	4.23%	26	3	18	5	78%	22%	3%	1%	1.3	7.97	2.33	10.3	10.3	6.3	0.52
KK	4.23%	26	5	12	9	57%	43%	2%	1%	1.3	6.83	1.05	7.88	7.88	3.88	0.52
MC	4.23%	26	3	11	12	48%	52%	2%	2%	1.3	3.58	0.98	4.56	4.56	0.56	0.52

Bank-C - SLA Performance By Major Region - May 2013 (Total: 515)

Site	Total Ticket (%)	Total Ticket	N/A	Exceed SLA By Site	Within SLA By Site	By Region		All Region		Average Ticket Per Day (20 days)	Communication Time Per Ticket (Hr)	Eng On-Site Per Ticket (Hr)	Resolution Time Per Ticket (Hr)	Resolution Time Per Ticket	Exceed Resolution SLA By…hr	FTE Benchmark (2.5 Ticket Per Engineer Per Day)
						Exceed SLA By Site (%)	Within SLA By Site (%)	Exceed SLA By Site (%)	Within SLA By Site (%)							
KL	51.17%	262	11	146	105	58%	42%	29%	21%	13.1	6.51	1.4	7.91	11	3.91	5.24
IP	7.62%	39	9	27	3	90%	10%	5%	1%	2.0	11.06	0.75	11.81	6	7.81	0.78
JB	6.45%	33	3	21	9	70%	30%	4%	2%	1.7	10.36	1.06	11.42	6	7.42	0.66
PG	5.86%	30	1	14	15	48%	52%	3%	3%	1.5	7.59	2.01	9.59	3	5.59	0.6
KC	2.54%	13	2	6	5	55%	45%	1%	1%	0.7	17.16	0.9	18.06	2	14.06	0.26
KK	2.73%	14	1	9	4	69%	31%	2%	1%	0.7	17.74	1.06	18.8	3	14.8	0.28
MC	4.69%	24	3	12	9	57%	43%	2%	2%	1.2	5.72	0.63	6.36	3	2.36	0.48
N9	5.27%	27	4	22	1	96%	4%	4%	0%	1.4	13.26	0.8	14.05	1	10.05	0.54

Bank-C - SLA Performance By Major Region - Apr 2013 (Total: 537)

Site	Total Ticket (%)	Total Ticket	N/A	Exceed SLA By Site	Within SLA By Site	By Region		All Region		Average Ticket Per Day (20 days)	Communication Time Per Ticket (Hr)	Eng On-Site Per Ticket (Hr)	Resolution Time Per Ticket (Hr)	Resolution Time Per Ticket	Exceed Resolution SLA By…hr	FTE Benchmark (2.5 Ticket Per Engineer Per Day)
						Exceed SLA By Site (%)	Within SLA By Site (%)	Exceed SLA By Site (%)	Within SLA By Site (%)							
KL	54.38%	292	25	136	131	51%	49%	28%	27%	14.6	4.69	1.47	6.16	13	2.16	5.84
IP	2.79%	15	3	9	3	75%	25%	2%	1%	0.8	4.54	0.58	5.12	4	1.12	0.3
JB	8.01%	43	4	29	10	74%	26%	6%	2%	2.2	7.1	0.81	7.91	5	3.91	0.86
PG	7.45%	40	5	15	20	43%	57%	3%	4%	2.0	3.52	1.01	4.53	1	0.53	0.8
KC	2.23%	12	1	5	6	45%	55%	1%	1%	0.6	3.1	1.29	4.39	3	0.39	0.24
KK	3.17%	17	5	11	1	92%	8%	2%	0%	0.9	7.59	0.95	8.54	2	4.54	0.34
MC	3.91%	21	1	10	10	50%	50%	2%	2%	1.1	3.18	1.07	4.25	4	0.25	0.42
N9	3.72%	20	1	18	1	95%	5%	4%	0%	1.0	19.97	1.35	21.32	2	17.32	0.4

Source: Case study analysis compilation

7.3.5.4 Pareto Diagram

Pareto analysis involves identifying the vital few contributors that account for most SLAs violation in an organization [30]. A Pareto analysis based on the collected data was carried out for Company-C. Pareto diagram is a histogram, or column charts that can help the research team to identify and prioritize problem areas. Pareto analysis also called the 80-20 rule; meaning that 80 percent of problems are often due to 20 percent of the causes.

It can observe from the Pareto Diagram in Figure 86 showed a high frequency of tickets violated resolution SLAs is caused by an unexpected increase of ticket volume sharing same pool of engineers crossed all project accounts which later reported delayed in ticket resolution. Major portion of the time were taken in the communication/coordination of ticket assignment, any delay in ticket closure will caused delay to communication/coordination time. The root-cause of recorded more than 50% of the tickets violated the resolution SLAs is due to: (1) Reactive mode in respond to ticket volume; (2) Sharing same pool of engineers crossed project accounts with different SLA target.

Source: Case study analysis compilation

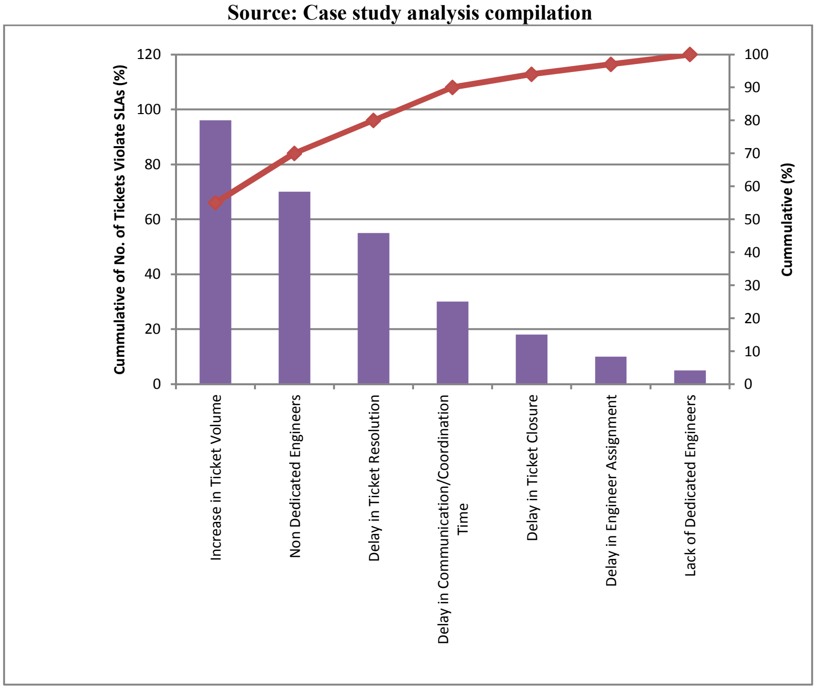


Figure 86 Pareto Diagram – Company-C

7.3.5.5 Six Sigma Calculation

The output measures approach undertaken is the output defections as a result of SLAs violation. Table 95 tabulated Six Sigma calculation for the case company covering SLAs resolution defections, SLAs response defections, SLAs resolution/response expire computation defection, ticket re-visit defection etc.

Table 95 Six Sigma Calculation – Company-C

SLA Performance Defection								
Description	**Defect**	*** Unit**	**Opportunity for error per unit ***		**No. of defects**	**No. of Units**	**DPMO**	**Sigma Level**
Account-2 (Bank-C) SLA Resolution Performance Defect **(General)**	Exceed Standard SLA Resolution Time **(General)**	Each Ticket exceeded standard SLA resolution time **(General)**	1 per ticket	Dec 2013	296	601	$\text{DPMO} = \left\{\frac{296}{601}\right\} \text{x } 10^6$ = 492,521	1.519
				Nov 2013	466	823	$\text{DPMO} = \left\{\frac{466}{823}\right\} \text{x } 10^6$ = 566,221	1.333
				June 2013	326	614	$\text{DPMO} = \left\{\frac{326}{614}\right\} \text{x } 10^6$ = 530,945	1.422
				May 2013	294	512	$\text{DPMO} = \left\{\frac{294}{512}\right\} \text{x } 10^6$ = 574,219	1.313
				April 2013	278	537	$\text{DPMO} = \left\{\frac{278}{537}\right\} \text{x } 10^6$ = 485,516	1.537
Account-2 (Bank-C) SLA Resolution Performance Defect **(KL Region)**	Exceed Standard SLA Resolution Time **(KL Region)**	Each Ticket exceeded standard SLA resolution time **(KL Region)**	1 per ticket	Dec 2013	113	243	$\text{DPMO} = \left\{\frac{113}{243}\right\} \text{x } 10^6$ = 465,021	1.588
				Nov 2013	172	368	$\text{DPMO} = \left\{\frac{172}{368}\right\} \text{x } 10^6$ = 467,391	1.582
				June 2013	157	285	$\text{DPMO} = \left\{\frac{157}{285}\right\} \text{x } 10^6$ = 550,877	1.372
				May 2013	146	251	$\text{DPMO} = \left\{\frac{146}{251}\right\} \text{x } 10^6$ = 581,673	1.294
				April 2013	136	267	$\text{DPMO} = \left\{\frac{136}{267}\right\} \text{x } 10^6$ = 509,363	1.477
Account-2 (Bank-C) Calculate Resolution SLA Defect	Calculated Resolution SLA when ticket is received	Each ticket with respective resolution SLA calculated	1 per ticket	June	277	614	$\text{DPMO} = \left\{\frac{277}{614}\right\} \text{x } 10^6$ = 451,140	1.623
Account-2 (Bank-C) Resolution SLA Computation Defect	Wrong Computation of Resolution SLA	Each Ticket wrongly computed for SLA resolution time	1 per ticket	Dec 2013	128	468	$\text{DPMO} = \left\{\frac{128}{468}\right\} \text{x } 10^6$ = 273,504	2.102
				Nov 2013	226	654	$\text{DPMO} = \left\{\frac{226}{654}\right\} \text{x } 10^6$ = 345,566	1.897
				June 2013	275	277	$\text{DPMO} = \left\{\frac{275}{277}\right\} \text{x } 10^6$ = 992,780	-0.946
				May 2013	148	316	$\text{DPMO} = \left\{\frac{148}{316}\right\} \text{x } 10^6$ = 468,354	1.579
Account-2 (Bank-C) Ticket Revisit Defect	Revisited previously attended ticket	Each ticket to be revisited	1 per ticket	June 2013	10	614	$\text{DPMO} = \left\{\frac{10}{614}\right\} \text{x } 10^6$ = 16287	3.637

SLA Performance Defection								
Description	**Defect**	*** Unit**	**Opportunity for error per unit ***		**No. of defects**	**No. of Units**	**DPMO**	**Sigma Level**
Account-2 (Bank-C) SLA Resolution Performance Defect **(General)**	Exceed Standard SLA Resolution Time **(General)**	Each Ticket exceeded standard SLA resolution time **(General)**	1 per ticket	Dec 2013	296	601	$DPMO = \left\{\frac{296}{601}\right\} x\ 10^6$ = 492,521	1.519
				Nov 2013	466	823	$DPMO = \left\{\frac{466}{823}\right\} x\ 10^6$ = 566,221	1.333
Account-3 (Bank-R) SLA Resolution Performance Defect	Exceed Standard SLA Resolution Time	Each Ticket exceeded standard SLA resolution time	1 per ticket	June 2013	110	718	$DPMO = \left\{\frac{110}{718}\right\} x\ 10^6$ = 153,203	2.532
Account-5 (Bank –M) Response SLA Performance Defect	Exceed Standard SLA Response Time	Each Ticket exceeded standard response SLA time	1 per ticket	April 2013	2	168	$DPMO = \left\{\frac{2}{168}\right\} x\ 10^6$ = 11,905	3.760
Account-5 (Bank –M) Resolution SLA Performance Defect	Exceed Standard SLA Resolution Time	Each Ticket exceeded standard resolution SLA time	1 per ticket	June 2013	7	168	$DPMO = \left\{\frac{7}{168}\right\} x\ 10^6$ = 41,667	3.232
Account-4 Governmen t Resolution SLA Performance Defect	Exceed Standard SLA Resolution Time	Each Ticket exceeded standard resolution SLA time	1 per ticket	June 2013	13	93	$DPMO = \left\{\frac{13}{93}\right\} x\ 10^6$ = 139,785	2.581
Account-1 Retailer Response SLA Performance Defect	Exceed Standard SLA Response Time	Each Ticket exceeded standard response SLA time	1 per ticket	April 2013	1	130	$DPMO = \left\{\frac{1}{130}\right\} x\ 10^6$ = 7,692	3.923
Account-1 Retailer Resolution SLA Performance Defect	Exceed Standard SLA Resolution Time	Each Ticket exceeded standard resolution SLA time	1 per ticket	April 2013	16	130	$DPMO = \left\{\frac{16}{130}\right\} x\ 10^6$ = 123,077	2.660

Source: Case study analysis compilation

Overall, the Sigma level for case company falls into the following category:

- Account-1: Between 2-sigma to 4-sigma (2σ < Account-1 < 4σ)
- Account-2: Between negative one (-1) sigma to 2-sigma (-1σ < Account-2 < 2σ)
- Account-3: Between 2-sigma to 3-sigma (2σ < Account-3 < 3σ)
- Account-4: Between 2-sigma to 3-sigma (2σ < Account-4 < 3σ)
- Account-5: Between 3-sigma to 4-sigma (3σ < Account-5 < 4σ)

The sigma performance of SLAs resolution for major site, i.e. KL, is between 1.2σ and 1.6σ (1.2σ < KL < 1.6σ) and all sites is between 1.3σ and 1.6σ (1.3σ < Account-2 < 1.6σ). Amongst the five project accounts, Account-2 has the least performing Six Sigma outcome of between -1σ and 2σ. The resolution SLAs computation defects for Account-2 was observed with negative sigma value which indicates that it is performing outside the case company specification range; i.e. 275 out of 277 tickets have SLAs expires wrong computed. Besides, the overall resolution performance defect is reported to be between 1.29σ and 1.58σ for KL region. There is ample room of improvements for Account-2 as there exists a significant gap of current SLAs performance against the benchmark of 3σ or 4σ as reviewed by Benes.

In summary, three out of five major project accounts for case company are facing violation in SLAs resolution. Significant and unpredictable tickets volume for month-to-be has triggered great impact on decision making to assign *x*-number of dedicated engineers to Account-2 but affecting the resolution performance as well as the level of effectiveness and efficiency in engineer utilization. A benchmark of core factor of engineer assignment against other key performance factors on ticket resolution time is indeed necessary to be used as basis to bench mark resource utilization optimization with optimized cost analysis. The case company is facing the challenge of long queues in ticket-engineer assignment with limited resources.

If substantial improvements or at least periodic gradual improvement toward SLAs resolution does not happen, the case company is at the risk of contract renewal which may affect the goodwill and competitiveness of the case company in the IT industry. Seeing an improvement in resolution SLAs and at least has the ability to cope and be proactive with future forecast is the key to case company continuous improvement and growth.

7.4 Analysis Phase

7.4.1 Introduction

IT Project management is the art of managing the project and its deliverables by utilizing a pool of available resources with a view to produce finished products or services [30]. There are many ways and methods in optimizing scarce resources in which a project can be carried out and the way in which it is executed in project management. The list of project management activities are identifying requirements, establishing clear and achievable objectives, balancing the competing demands from the different stakeholders and ensuring that a commonality of purpose is achieved.

In the context of Company-C, IT project management for IT Services should aims to provide a competitive advantage for organizations seeking to improve services with the aid of technology service capabilities. The goal is to deliver value to the business while managing the project's four constraints; schedule (tickets are resolved within SLAs), budget (within planned costing), scope (only tickets within contractual scope are resolved) and quality (95% of ticket are resolved within contractual SLAs). In cases where constraints are mismanaged, the overall project as a whole would be impacted. Therefore, the case company's approach in root-cause identification involve process investigation, process improvement and focus on developing solutions to eliminate the root causes of business performance problems. In essence, the aim is for a continuous process improvement effort which seeks to fix a problem while leaving the basic operational structure of the work process intact.

After the data collection and data measuring process, all the possible causes of defection or hypotheses were shortlisted:

- Most project accounts that violated the contractual SLAs are due to long awaiting time when assigning tickets to engineer, i.e. deficiency in Coordination/Communication. The level of SLAs violation varies among project accounts.
- Tendencies of delayed tickets closure when the tickets are resolved.
- Conflict and confusion of ticket handling by an engineer due to tickets across project accounts having different SLAs.
- Despite the lack of ticket tracking mechanism where redundant and overlapping of effort was observed in follow-up after tickets were assigned, the project team faced much rework and yet there remained a significant amount of SLAs violation.

Despite data observation in the measure phase, the research team opted to further the investigation into workflow processes using a high-level process map, input-process-variables process map as well as looking into case company's operational framework, and ways of resource allocation and utilization. The main objective in the Analysis phase is to ensure all incidents are investigated and root causes are identified. Consequently, corrective action will be proposed based on the reviewed trends and identified gaps, whereby improvement plans can be developed to prevent future occurrences.

7.4.2 Tools and Techniques

7.4.2.1 High Level Process Mapping

Upon project investigation, a summary of the general view of case company's operational activities is shown in Figure 88. The operational overview was presented in the business nature of break-fixes showing break-fix activities involved in the vendor-client relationship. It also outlined how each ticket is undertaken until it is resolved with a ticket closure.

The "big picture" of Company-C's business and cross-functional for break-fix activities can be described in a broader overview using the Escalation of Break-Fix Activity Flow (Figure 87). Whenever a break-fix is reported, the vendor will contact Company-C by sending an email to Helpdesk. A new ticket will be logged and put into a queue monitoring system according to severity level and resolution SLA. Tickets received will be analyzed and assigned to an engineer. Assigned engineers will schedule for an on-site diagnostic and the ticket will revert to QM once resolved. In the event the ticket is left unresolved within the first visit, the ticket will be escalated to the backend (or second level diagnostic), which is overseen by a senior engineer. In cases relating to hardware warranty issues, the ticket will be passed-on to the hardware vendor for warranty support and further follow-up diagnosis. Based on the current operational framework, the high level process map, input-process-variable and flow chart for the case company break-fix project accounts are outlined in Figure 87, Figure 88, and Figure 89 respectively.

Source: Case study analysis compilation

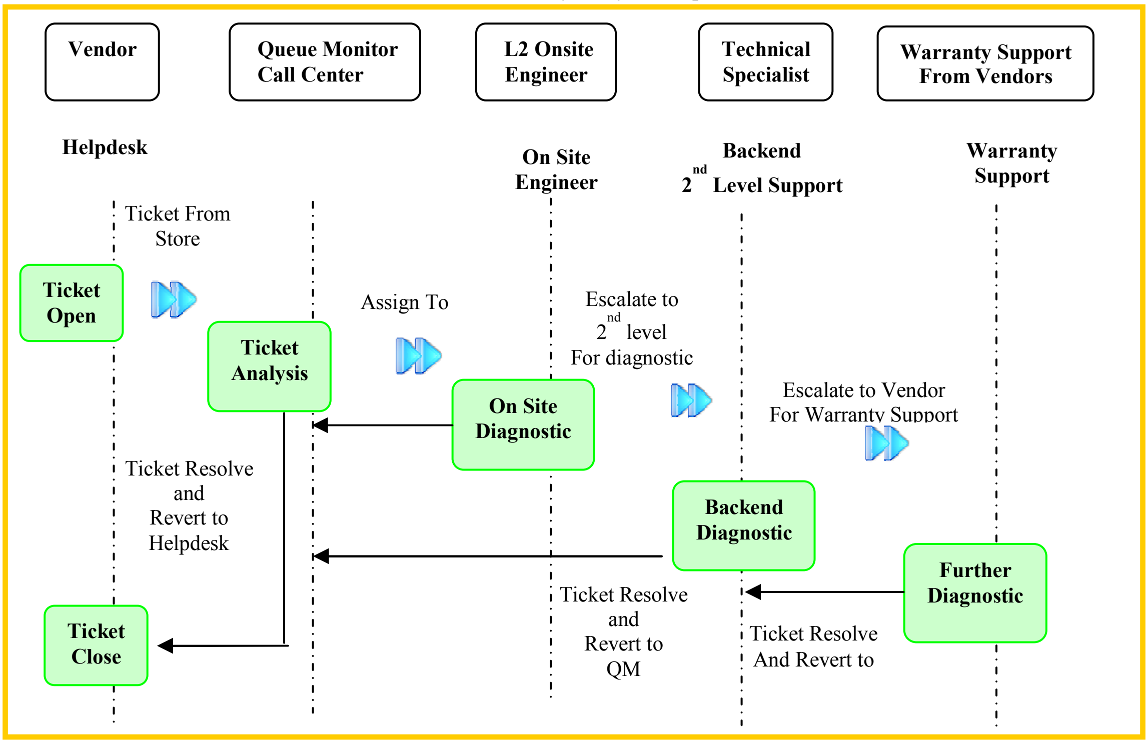


Figure 87 Company-C: Escalation of Break-Fix Activity Flow

Source: Case study analysis compilation

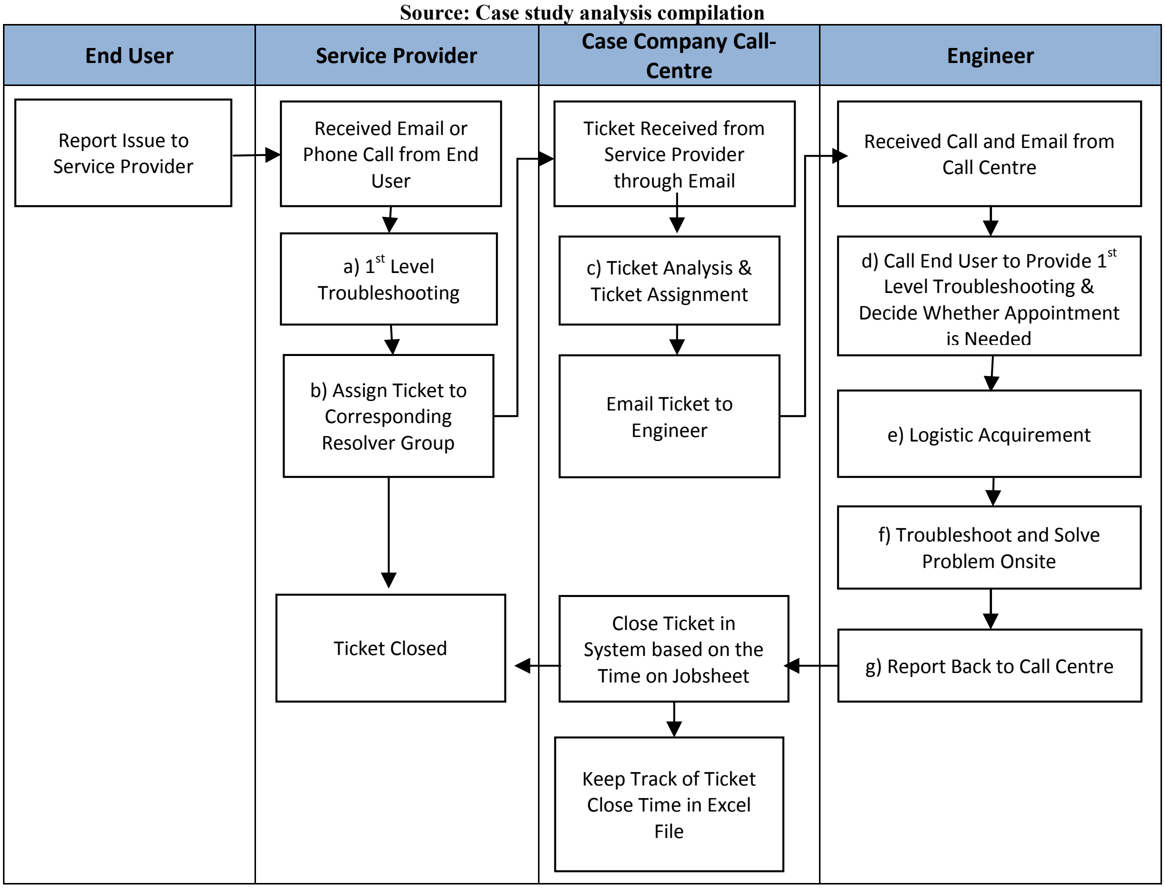


Figure 88 Company-C: High Level Process Map (Current Break-Fix Routine)

7.4.2.2 Input-Process-Variables

Source: Case study analysis compilation

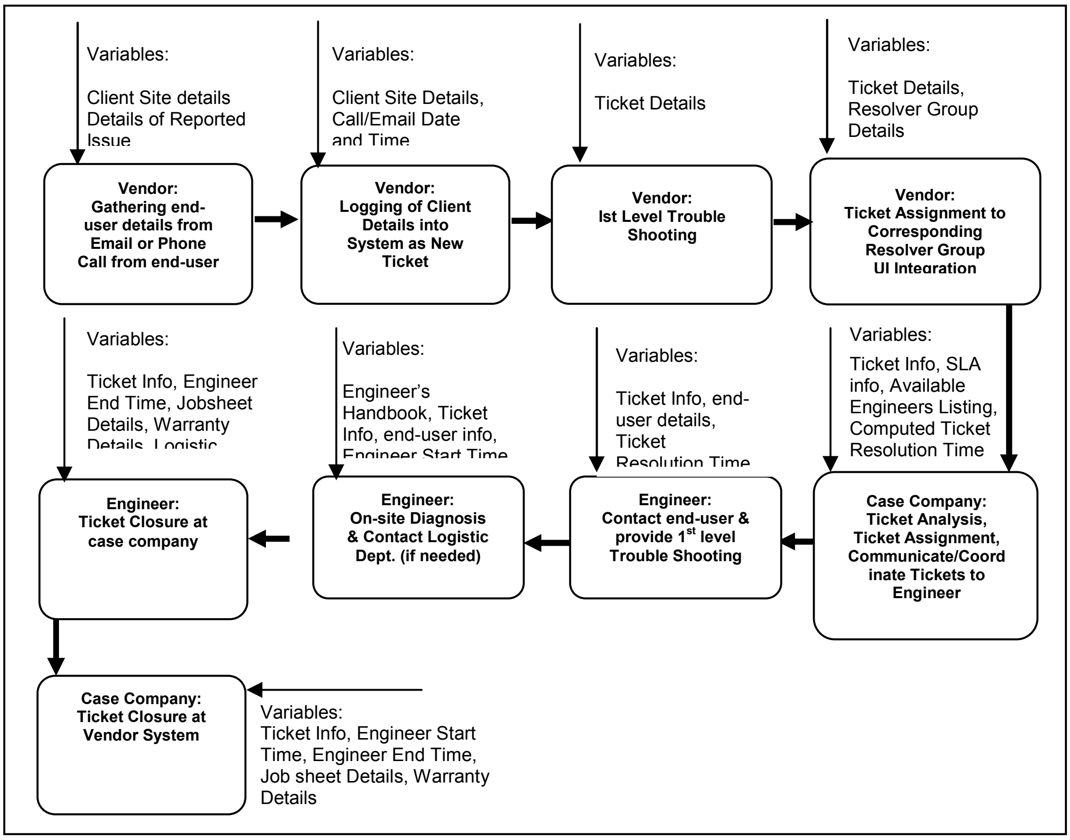


Figure 89 Company-C: Input-Process-Variables Process Map (Current Break-Fix)

By benchmarking collected input variables from Figure 89, the research team tabulated a listing of critical variables and controllable variables for respective sub-processes. The identification of critical variables in Table 96 are consistent with findings resulting from the measure phase, i.e. SLA performance, duration of communication/coordination and current operational framework are the potential areas to focus on as opportunities for continuous improvement.

Table 96 Company-C: Critical and Controllable Variables

Process	Critical Variables	Controllable Variables
Vendor: Gathering end-user details from Email or Phone	End-user details, Details of reported issue	Completeness of End-user details and details of reported issue
Vendor: Logging of Client Details into System as New Ticket	Client Site Details, Details of reported issue, Call/Email Date and Time	Completeness of End-user details and details of reported issue
Vendor: 1st Level Trouble Shooting	Vendor's engineer participation, Result of 1st Level Trouble Shooting	Ticket categorization by assistance and utilization of handbook
Vendor: Ticket Assignment to Corresponding Resolver Group	Category of Ticket Assignment by Vendor	Ticket Severity Level, Ticket Category Assignment
Case Company: Ticket Analysis, Ticket Assignment and Communicate / Coordinate Ticket to Engineer	Available standby Engineers, Technical knowledge and Experience of engineer	Prioritize ticket by effectively and efficiently assigning ticket to engineer for tickets with short-span of resolution time
Engineer: Contact end-user & provide 1st level Trouble Shooting	Ability of engineer in probing question and simulation of reported problem	Engineer's Probing Skill, Sharing of Engineer's knowledge and exposure of similar cases
Engineer: On-site Diagnosis & Contact Logistic Dept. (if needed)	Ticket Communication/Coordination time, Engineer's ability in managing own tickets	Efficient and effective mechanism of ticket tracking, controlling and managing ticket to meet resolution time
Engineer: Ticket Closure at case company	Initiative and Awareness of Individual Engineer regarding the importance of ticket closure	Helpdesk support staff to follow-up with ticket closure
Case Company: Ticket Closure at Vendor System	Engineer Start Time, Engineer End Time, Jobsheet Details, Warranty Details, Resolution Time	Engineer to provide all necessary information for ticket closure

7.4.2.3 Flow Chart: Break-Fix Activity

Although the majority of the outsourcing services in the case company fall into the category of break-fixes, the nature of each account's break-fix varies amongst business nature across the industries. For example, real-time break-fix in the banking and airline industry are time-critical and every second of down-time cost millions of dollars; whereas the SLA tolerance level for hardware break-fixes in most retailer chains are less stressful as replacement and swapping of hardware can be done easily by providing temporary solutions without affecting daily business operational routines. Hence, to better understand the root-cause of business activity and business flow for Account-2, a break-fix flow chart for Account-2 is outlined in Figure 90. The details of the break-fix workflow were discussed in section 7.4.2.

7.4.2.4 Cause-and-Effect Diagram

Once the case study's operational work flow has been compiled into a high level process map, input-process-variables process map and flow chart, a "structured brainstorming" method to identify the root-cause of the potential problems are identified. The Cause and Effect diagram is a great tool for gathering group ideas and input by establishing categories of potential causes, rather than just focusing on a few typical areas. The cause-and-effect diagram for Company-C is depicted in Figure 91. The findings of *measurement* (i.e. Coordination time is a factor affecting SLA achievement, Resolution SLA towards bottom time), *materials* (i.e. All accounts sharing same pool of engineers, Not meeting SLA) and *procedure* (i.e. Redundant/Overlap effort for ticket tracking, monitoring and closure) from the Cause and Effect diagram are consistent with statistics and theory compiled from the Measure phase. The element of "Method", "Technology" and "Mother Nature" are the potential areas pending to be addressed in the current investigation. An in-depth analysis is required to pinpoint how current operational work flow may affect the overall resource allocations as well as work effectiveness and efficiencies.

7.4.2.5 Failure Modes and Effects Analysis (FMEA)

Upon completing the investigation using several tools mentioned in the Analysis phase, three brainstorming sessions with Ms. Wong were conducted with the operations manager. Potential causes were listed for each failure in the FMEA table. The operation manager was briefed on the Risk Priority Number (RPN) table. Once the RPN was assigned to each potential failure in the FMEA table, the RPN and list the potential failures was computed in descending priority order for improvement suggestions as shown in Table 97. The top three potential failures gathered from the FMEA analysis are: (1) Long queue of tickets waiting for ticket-engineers assignment especially for banking account; (2) SLAs breach has become "common" and "norm" to both support team and service team; (3) Coordination time is a factor contributing to delay in resolution SLA.

Source: Case study analysis compilation

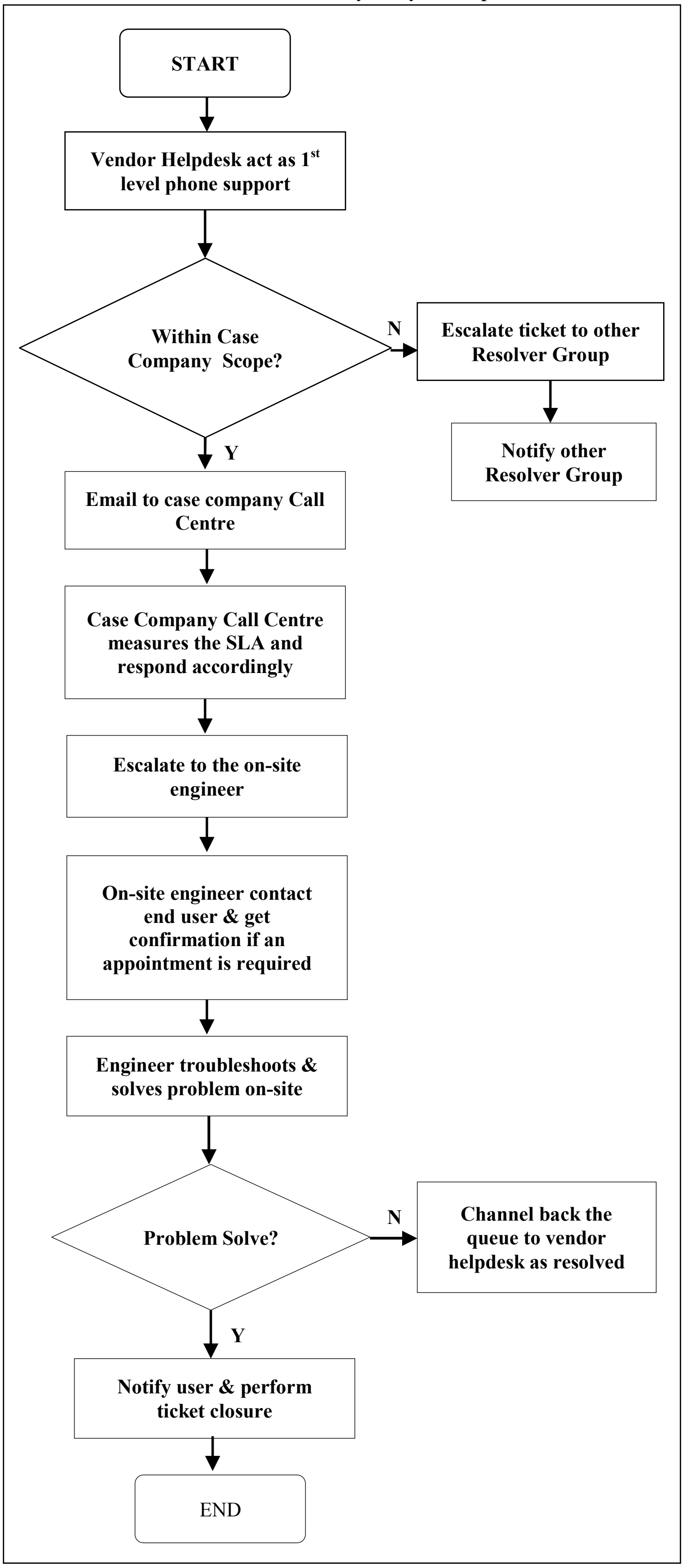


Figure 90 Company-C: Break-Fix Flow Chart

Tools and Techniques: Fishbone Diagram / Cause–and-Effect Diagram / Ishikawa Diagram (Response and Resolution SLA)

Source: Case study analysis compilation

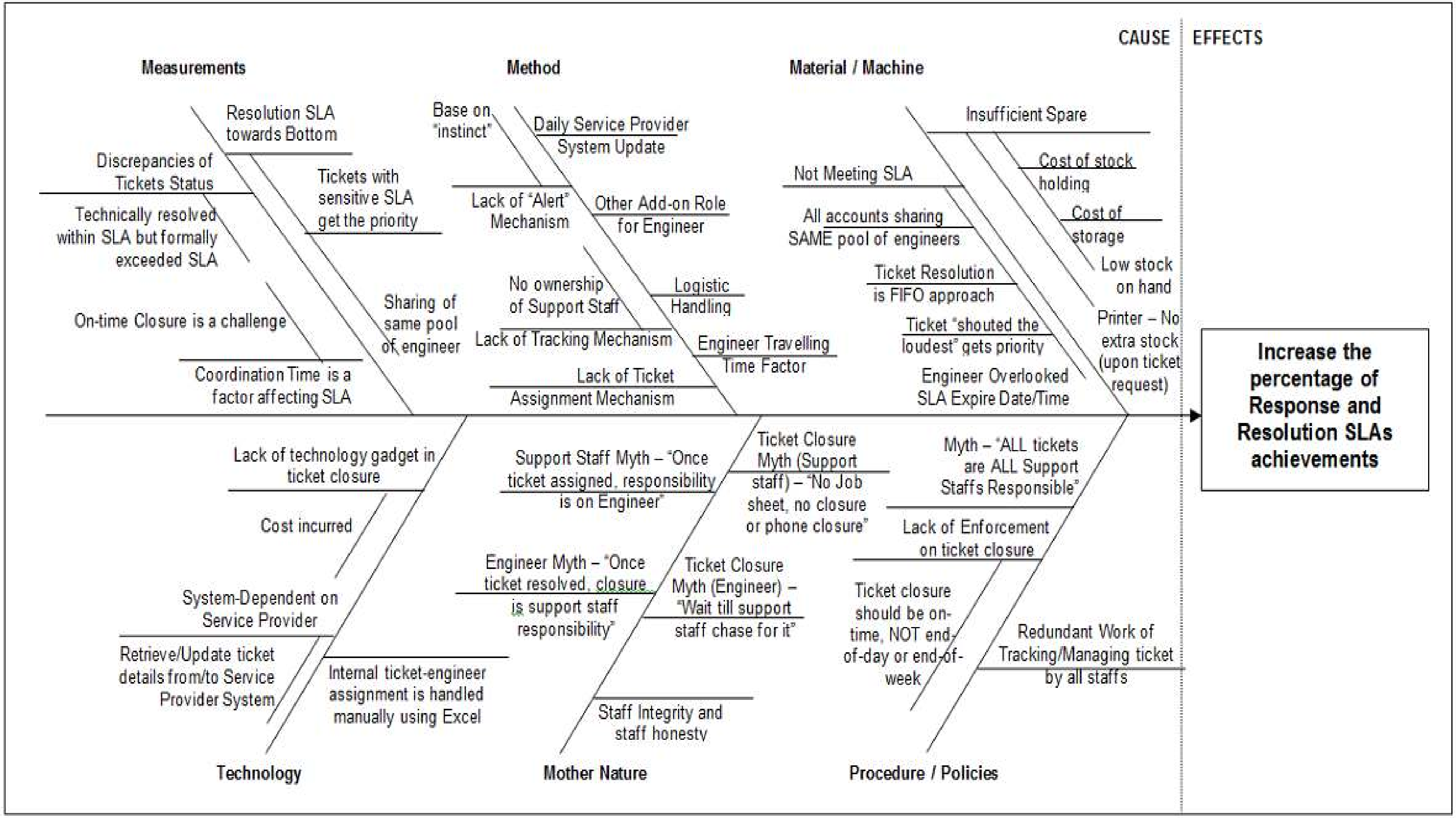


Figure 91 Cause and Effect Diagram –Case Company

Table 97 Failure Mode and Effects analysis – Company-C

Potential Failure Modes	Potential Causes	Current Controls	Risk Priority Number (RPN)				Recommended Action
			Severity	Occurrence	Detection	RPN	
Long waiting queue of engineers (banking account) for lower priority banking account	• Only engineers in the banking account can take on banking tickets • Engineers in banking account can take non-banking account • High volume of banking tickets per day per engineer • Inappropriate ration proportion of tickets to engineer	Banking account is given priority	10	10	10	1000	• Increase number of engineer • Dedicated engineer to "a" banking account • All banking account deserved to have equal attentiveness in SLA resolution
Exceed SLA for certain account has become "common" and "norm" to both support team and service team	• Culture of "exceed SLA" has been seen "common" and "norm" among service and support team as banking account needed to be given priority • On-time closure by engineer is an issue faced by most accounts • No KPI set for ticket closure • Account with accumulated pending tickets are not being escalated	Not proactive but reactive approach	10	10	9	900	• Procedure for ticket closure should be enforced and tracked for individual engineer KPI achievement • SLA target should be enforced by support lead and service lead to support staff and engineers • Usage of Smart Phone for on-time closure
Coordination time is a factor contributing to Resolution SLA	• Improving coordination will improve Resolution time • More than 70% of total Resolution time is spent on ticket coordination • Engineer Travelling Time is a major contribution to resolution SLA • Additional add-on role for engineer • Lack of efficiency and effectiveness of ticket tracking and follow-up by support staff • Much effort was spend on chasing for closure	No Control	9	9	8	648	• Development of ways to improve coordination time for ticket assignment, ticket tracking, ticket follow-up and ticket closure between support staff and engineer • Development of suggestions and ways to reduce engineer travelling time • Enforce the operational routine of on-time ticket closure, rather than weekly-basis closure • To opt for engineer to close ticket
Tendency of delayed updating Resolution SLA into Service Provider System as long as tickets are resolved (Jobsheet) within SLA	• Support Staff overlooked of tracking the resolution closure SLA • Unable to perform closure due to missing of job sheet	No Control – manual tracking	8	8	8	512	• Alert mechanism for ticket closure • Time marker for different ticket status • Implementing internal ticket handling performance marker by support staff/engineer
Lack of ticket tracking mechanism	• No ticket ownership • Tracking based on "instinct" • Lack of communication between support staff and engineers	No Control	8	8	7	448	• Each ticket should assigned to a support staff and an engineer • Engineer should coordinate with assigned support staff for resolution closure
Redundant and Overlapping of effort in tracking and follow-up assigned ticket	• No ticket ownership • Myth – EVERY support staff needs to oversee EVERY ticket • Lack of focus	No Control	8	7	7	392	• Each ticket should assigned to a support staff • Assigned support staff is responsible for the ticket Response SLA and Resolution SLA
A large portion of expenditures falls into Phone Bills	• Phone calls from support: (1) in-house-phone to mobile phone (2) mobile to in-house-phone • Phone calls asking regarding details of tickets by engineer • Phone calls chasing for closure • Phone calls chasing for phone closure	No Control	5	5	5	125	• Awareness of cost saving phone call making among engineer and support staff • Should reduce or eliminate phone closure as it take up much time and phone charges • Suggestion of ticket closure using smart phone

Potential Failure Modes	Potential Causes	Current Controls	Risk Priority Number (RPN)				Recommended Action
			Severity	Occurrence	Detection	RPN	
Discrepancies of Ticket Response/Resolution SLA between service provider system and internal report	Using informal discretions of meeting SLA	No Control	5	5	5	125	Internal report should reflect actual SLA achievement
IT Knowledge Management – Technical incidents are not recorded for future sharing	• Technical incident issues are not shared among engineers • Only engineers experienced/attended the incident will know the issue. Sometimes engineer may forgotten about the incident • Lack of centralized knowledge sharing on 'irregular repeated incident"	No control	5	5	5	125	• Engineer lead to compile monthly incident/knowledge sharing from respective account • Suggest to have periodic technical conference (once to twice a year) among engineers from different regions to share and acquire technical experience and knowledge
Accuracy and reliability of internal SLA reporting	• Greatly dependent on staff's integrity and honesty • No/Lack-of internal tracking, controlling and managing of respective account	No control	2	2	2	8	• Suggestion of random pick of quality assurance on SLA related activities • Suggestion of monthly SLA achievement report for EVERY account to ensure overall SLA health and risk
Others • Mileage claim (central region) • Reward (Engineer and Support Staff) • Smart Phone Data Plan	Mileage Claim • Busy traffic during office hour is limiting mileage claim but fuel usage is still running during traffic congestion • Current mileage policy is not favour to central region cause low mileage but high fuel consumption	No control	9	9	9	729	Mileage Claim • To revise current mileage claim base on "standard" rate (adopted by most IT company) • Only central region is affected. Other region remains the same.
	Smart Phone Data Plan Late/Delayed ticket closure is due to technology enabler – smart phone	No control	6	6	6	216	Smart Phone Data Plan To provide data plan to engineers who served SLA sensitive account
	Reward • Lack of work motivation as there is no recognition from management	No control	5	5	5	125	Reward • Suggestion of rewards by region by proportion of staff ration

Source: Case study analysis compilation

Risk Priority Number (RPN) Guideline

Severity	
Rating	**Meaning**
1	No effect
2	Very minor (only noticed by discriminating customers)
3	Minor (affects very little of the system, noticed by average customer)
4/5/6	Moderate (most customers are annoyed)
7/8	High (causes a loss of primary function; customers are dissatisfied)
9/10	Very high and hazardous (product becomes inoperative; customers angered; the failure may result unsafe operation and possible injury)

Occurrence	
Rating	**Meaning**
1	No known occurrences on similar products or processes
2/3	Low (relatively few failures)
4/5/6	Moderate (occasional failures)
7/8	High (repeated failures)
9/10	Very high (failure is almost inevitable)

Detection	
Rating	**Meaning**
1	Certain - fault will be caught on test
2	Almost Certain
3	Low
4/5/6	Moderate
7/8	High
9/10	Fault will be passed to customer undetected

7.4.2.6 Analysis of Ticket Assignment and Engineer Utilization

7.4.2.6.1 Introduction to Ticket-Engineer Assignment

Due to its business nature, the case company has its engineers trained at an equally high level and is equipped with a wide range of experience for different project accounts. In order to optimize and maximize engineers' utilization, **all project accounts share the same pool of resources**. Although this way of resource sharing is believed to be more cost effective, it does not align with the case company business directives and long term goals; particularly in the KL region where Account-2 has a reported 53%, 56% and 53% Resolution SLAs violation in April, May and June respectively. Therefore, further analysis on ticket-engineer assignment was explored to establish how the ticket-engineer assignment mechanism contributes to SLAs performance.

Table 98 Account-2: FTE vs SLA Violation (KL)

Month	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	Jun 2013
Region-KL	160	156	223	317	273	269
FTE-KL	8	8	8	13	11	5
SLA Violation-KL	N/A	N/A	N/A	53%	56%	53%

Source: Case study analysis compilation

Table 98 outlines total tickets attended for Account-2 in KL region between Jan-June 2013. It can be observed that ticket volume are steadily increasing for the first three months and in total eight engineers from common pool of resources are involved. These engineers are non-dedicated engineers for Account-2, where they are required to serve other project accounts accordingly. Reacting to unpredictable increased mass of ticket volume in April, thirteen engineers are utilized with 53% violation in SLAs performance. When the number of tickets reduced in the following month of May, only eleven engineers are utilized with reported SLAs violation of 56%.

In view of the engineer assignments as being reactive to unpredictable ticket volume; analysis was carried out to assign five dedicated engineers to Account-2 and have the SLAs performance observed in the month of June 2013. The outcome revealed that with five dedicated engineers assigned to Account-2 serving 269 tickets, the SLAs violation for Jun is 53% as opposed to 56% in May when eleven non-dedicated engineers were assigned. It show that the approach of assigning dedicated engineers in the month of June has improved resource usage by 55% (i.e. from eleven to five engineers) and thus achieving the relatively similar SLAs violation of 56% and 53% respectively for the month of May and June. As a result, five dedicated engineers will continued to be assigned to project-B for months to come. The details of how five dedicated engineers can perform better are discussed in the following section.

7.4.2.6.2 Engineer Utilization Simulation

Table 99 outlines simulation of resources utilization under different scenarios based on historical data provided by the case company where tickets across all project accounts are shared amongst the same pool of engineers. A number of assumptions and the basis of historical data for each project account were used in the simulation as described below:

- On average, each engineer capable of attending 2-3 tickets per day.
- Engineers trained for similar service category (e.g. Banking, Retailer etc.) will be assigned to related project account, e.g. Account-2 and Account-3 are two project accounts from the same category.
- The simulation only involves "incident" cases.
- Based on the contractual SLA agreement, the Resolution SLA for incident Account-2 is 4.0 working hours and Account-3 has two category of Resolution SLA: (1) P1 is 3.0 working hours; (2) P2 is 6.0 working hours.
- Based on the historical data, the average engineer-onsite-time for Account-2 and Account-3 is 1.5 hours and 2.5 hours respectively.
- Within the simulation, it is assumed that support staff requires to seek advice from Lead Engineer in charge prior to each ticket-engineer assignment. Only the Lead Engineer has the latest information about engineer assignment allocation. This assumption does not applied to ticket-engineer assignment within the same project account.
- The travelling time from one place to another within the same region (i.e. KL) is estimated to be 0.5 hour.
- Based on the historical data, for tickets <u>within</u> the same project account, the gap between two tickets is 1.0 hour instead of 0.5 hour across project account.
- For tickets <u>within</u> the same project account, support staff will bypass Lead Engineer in ticket-engineer assignment. Support staff can assign the ticket directly to any engineer but keeping Lead Engineer in the assignment loop.

Table 99 Account-2: Ticket Simulation By Engineer

Ticket Simulation By Engineer - Different Combination Scenario Between Account-2 and Account-3								
History Data	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-2	9:00 am	9:30 am	1:00 pm	10:00 am	11:30 am	0:30 hr	Within SLA	
Ticket-2 Account-3 (P2)	9:30 am	10:00 am	3:30 pm	12:00 pm	2:30 pm	2:00 hr	Within SLA	
Ticket-3 Account-3 (P2)	10:00 am	10:30 am	4:00 pm	3:00 pm	5:30 pm	4:30 hr	Exceed SLA	1:30 hr
	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-2	9:00 am	9:30 am	1:00 pm	10:00 am	11:30 am	0:30 hr	Within SLA	
Ticket-2 Account-3 (P1)	9:30 am	10:00 am	12:30 pm	12:00 pm	2:30 pm	2:00 hr	Exceed SLA	2:00 hr
Ticket-3 Account-3 (P2)	10:00 am	10:30 am	4:00 pm	3:00 pm	5:30 pm	4:30 hr	Exceed SLA	1:30 hr
	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-2	9:00 am	9:30 am	1:00 pm	10:00 am	11:30 am	0:30 hr	Within SLA	
Ticket-2 Account-3 (P2)	9:30 am	10:00 am	3:30 pm	3:00 pm	5:30 pm	5:00 hr	Exceed SLA	2:00 hr
Ticket-3 Account-3 (P1)	10:00 am	10:30 am	1:00 pm	12:00 pm	2:30 pm	1:30 hr	Exceed SLA	1:30 hr
	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-2	9:00 am	9:30 am	1:00 pm	10:00 am	11:30 am	0:30 hr	Within SLA	
Ticket-2 Account-3 (P1)	9:30 am	10:00 am	12:30 pm	12:00 pm	2:30 pm	2:00 hr	Exceed SLA	2:00 hr
Ticket-3 Account-3 (P1)	10:00 am	10:30 am	1:00 pm	3:00 pm	5:30 pm	4:30 hr	Exceed SLA	4:30 hr
History Data	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-2	9:00 am	9:30 am	1:00 pm	10:00 am	11:30 am	0:30 hr	Within SLA	
Ticket-2 Account-3 (P2)	9:30 am	10:00 am	3:30 pm	2:00 pm	4:30 pm	4:00 hr	Exceed SLA	1:00 hr
Ticket-3 Account-2	10:00 am	10:30 am	2:30 pm	12:00 pm	1:30 pm	1:30 hr	Within SLA	
History Data	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-2	9:00 am	9:30 am	1:00 pm	10:00 am	11:30 am	0:30 hr	Within SLA	
Ticket-2 Account-3 (P1)	9:30 am	10:00 am	12:30 pm	12:00 pm	2:30 pm	2:00 hr	Exceed SLA	2:00 hr
Ticket-3 Account-2	10:00 am	10:30 am	4:00 pm	3:00 pm	5:30 pm	4:30 hr	Exceed SLA	1:30 hr

Ticket Simulation By Engineer - Different Combination Scenario Between Account-2 and Account-3								
	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-3 (P2)	9:00 am	9:30 am	3:00 pm	10:00 am	12:30 am	0:30 hr	Within SLA	
Ticket-2 Account-2	9:30 am	10:00 am	1:30 pm	1:00 pm	2:30 pm	3:00 hr	Exceed SLA	1:30 hr
Ticket-3 Account-2	10:00 am	10:30 am	2:00 pm	3:00 pm	4:30 pm	4:30 hr	Exceed SLA	2:30 hr
	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-3 (P1)	9:00 am	9:30 am	12:00 pm	10:00 am	12:30 pm	0:30 hr	Exceed SLA	0:30 hr
Ticket-2 Account-2	10:00 am	10:00 am	1:30 pm	1:00 pm	2:30 pm	3:00 hr	Exceed SLA	1:30 hr
Ticket-3 Account-2	11:00 am	10:30 am	2:00 pm	3:00 pm	4:30 pm	4:30 hr	Exceed SLA	2:30 hr
	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-3 (P1)	9:00 am	9:30 am	12:00 pm	10:00 pm	12:30pm	0:30 hr	Exceed SLA	0:30 hr
Ticket-2 Account-3 (P1)	9:30 am	10:00 am	12:30 pm	1:00 pm	3:30 pm	3:00 hr	Exceed SLA	3:00 hr
Ticket-3 Account-3 (P1)	10:00 am	10:30 am	1:00 pm	4:00 pm	6:30 pm	5:30 hr	Exceed SLA	5:30 hr
	Ticket-Time-In	Engineer-Received-Ticker	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-3 (P2)	9:00 am	9:15 am	3:00 pm	9:45 pm	12:15 pm	0:30 hr	Within SLA	
Ticket-2 Account-3 (P2)	10:00 am	10:15 am	4:00 pm	12:45 pm	3:15 pm	3:00 hr	Within SLA	
Ticket-3 Account-3 (P2)	11:00 am	11:15 am	5:00 pm	3:45 pm	6:15 pm	5:30 hr	Exceed SLA	1:15 hr
	Ticket-Time-In	Engineer-Received-Ticket	Ticket SLA Expire	Engineer-Time-In	Engineer-Time-Out	Engineer Received Ticket until Engineer is available on-site	SLA Performance	Exceed By
Ticket-1 Account-2	9:00 am	9:15 am	1:00 pm	9:45 am	11:15 am	0:30 hr	Within SLA	
Ticket-2 Account-2	10:00 am	10:15 am	2:00 pm	11:45 pm	1:15 pm	1:30 hr	Within SLA	
Ticket-3 Account-2	11:00 am	11:15 am	3:00 pm	1:45 pm	3:15 pm	2:30 hr	Exceed SLA	0:15 hr

Source: Case study analysis compilation

Table 100 Account-2: Summary of Ticket Simulation By Engineer

Ticket combination Sequence	SLA Performance		
	Within SLA (%)	Exceed SLA (%)	Total Exceed Time
A2→A3(2)→A3(2)	67%	33%	1:30 hr
A2→A3(2)→A2	67%	33%	1:00 hr
A3(2)→A3(2)→A3(2)	67%	33%	1:15 hr
A2→A2→A2	67%	33%	0:15 hr
A2→A3(1)→A3(2)	33%	67%	4:00 hr
A2→A3(2)→A3(1)	33%	67%	4:00 hr
A2→A3(1)→A3(1)	33%	67%	7:00 hr
A2→A3(1)→A2	33%	67%	3:30 hr
A3(2)→A2→A2	33%	67%	4:00 hr
A3(1)→A2→A2	0%	100%	4:30 hr
A3(1)→A3(1)→A3(1)	0%	100%	9:00 hr

Note : A2→A3(2)→A3(2) denotes 1st ticket is Account-2, 2nd ticket is Account-3 with severity-2, 3rd ticket is Account-3 with severity-2

Source: Case study analysis compilation

The summary of ticket simulation among Account-2 and Account-3 is outlined in Table 100. It was observed that tickets combination with "same SLA resolution duration (shaded grey)" performed better than tickets combination with "different SLA resolution duration". This result indicated that for tickets with "same SLA resolution duration", the total time exceeded SLA is only 15 minute and 1 hour 15 minute as compared to tickets with "different SLA resolution duration", which recorded an overwhelming 9 hours, 7 hours, 4 hours and 3 hours etc.

Therefore, this simulation showed that ticket-engineer assignment for ticket with "same SLA resolution duration" is significantly more effective and efficient as compared to tickets with "different SLA resolution duration". It is proven in Table 100 that 75% of tickets from the category of "different SLA resolution duration" were reported with SLA violation. Hence, it is important to have "dedicated" engineers trained with necessary technical skill-set and equipped with relevant technical knowledge serving "a" particular project account. This is particularly valid when the SLA resolution duration of a project account is relatively short (i.e. between 3-6 hours). The simulation results derived from this ticket-engineer assignment has allowed the research team to extend the analysis into utilization of dedicated engineers within the same project account to improve SLA resolution performance. The large pool of resources from the case company enables competent deployment of knowledgeable staff whenever possible.

7.4.2.6.3 Engineer Resource Utilization

In view of the high Ticket-To-Engineer ratio in KL region, a set of live data for the month of June was used to benchmark ticket assignment amongst five, six, seven, eight and nine engineers for the purpose of resource utilization. The one-day performance output of "Total Tickets Attended", "Total Tickets Within SLAs" and "Total Tickets Exceed SLAs" are recorded in Table 101. This benchmarking simulation was carried out with the following assumptions:

- Tickets are performed by 5, 6, 7, 8 and 9 experienced and dedicated engineers. Engineers attended Account-2 are not made possible to other project account.
- Average engineer on-site time is 1.5 hour.
- Average coordination/Communication time is 1.0 hour.
- There will be one engineer performing at 75% capacity and the rest at 100% capacity.

Since Account-2 has the least buffer time in resolution SLA (i.e. 4 working hours for incident tickets and 3 days for IMAC issues), it is important to perform simulation with different combinations of engineers assigned.

Table 101 Account-2: Summary of Resource Utilization Simulation

<table>
<tr><th>FTE</th><th colspan="2">FIVE (5) Engineers</th><th></th><th colspan="2">SIX (6) Engineers</th><th></th><th colspan="2">SEVEN (7) Engineers</th><th></th><th colspan="2">EIGHT (8) Engineers</th><th></th><th colspan="2">NINE (9) Engineers</th></tr>
<tr><td></td><td>Qty</td><td>%</td><td></td><td>Qty</td><td>%</td><td></td><td>Qty</td><td>%</td><td></td><td>Qty</td><td>%</td><td></td><td>Qty</td><td>%</td></tr>
<tr><td>Tickets Attended</td><td>15</td><td>60%</td><td></td><td>18</td><td>72%</td><td></td><td>20</td><td>80%</td><td></td><td>22</td><td>88%</td><td></td><td>23</td><td>88%</td></tr>
<tr><td>Tickets Within SLA (1st day)</td><td>10</td><td>40%</td><td></td><td>13</td><td>52%</td><td></td><td>16</td><td>64%</td><td></td><td>21</td><td>84%</td><td></td><td>23</td><td>88%</td></tr>
<tr><td>Tickets Exceed SLA (1st day)</td><td>5</td><td>20%</td><td></td><td>5</td><td>20%</td><td></td><td>4</td><td>16%</td><td></td><td>1</td><td>4%</td><td></td><td>0</td><td>0</td></tr>
<tr><td>Tickets To Next Business Day (NBD)</td><td>10</td><td>40%</td><td></td><td>7</td><td>28%</td><td></td><td>5</td><td>20%</td><td></td><td>3</td><td>12%</td><td></td><td>2</td><td>12%</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Resource Utilization</td><td>%</td><td>Average</td><td></td><td>%</td><td>Average</td><td></td><td>%</td><td>Average</td><td></td><td>%</td><td>Average</td><td></td><td>%</td><td>Average</td></tr>
<tr><td>Engineer #1</td><td>75%</td><td rowspan="5">95%</td><td></td><td>100%</td><td rowspan="6">100%</td><td></td><td>75%</td><td rowspan="7">96.4%</td><td></td><td>75%</td><td rowspan="8">93.75%</td><td></td><td>75%</td><td rowspan="9">69.4%</td></tr>
<tr><td>Engineer #2</td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>75%</td></tr>
<tr><td>Engineer #3</td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>75%</td></tr>
<tr><td>Engineer #4</td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>75%</td></tr>
<tr><td>Engineer #5</td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>75%</td></tr>
<tr><td>Engineer #6</td><td>-</td><td>-</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>50%</td></tr>
<tr><td>Engineer #7</td><td>-</td><td>-</td><td></td><td>-</td><td>-</td><td></td><td>100%</td><td></td><td>75%</td><td></td><td>50%</td></tr>
<tr><td>Engineer #8</td><td>-</td><td>-</td><td></td><td>-</td><td>-</td><td></td><td>-</td><td>-</td><td></td><td>100%</td><td></td><td>50%</td></tr>
<tr><td>Engineer #9</td><td>-</td><td>-</td><td></td><td>-</td><td>-</td><td></td><td>-</td><td>-</td><td></td><td>-</td><td>-</td><td></td><td>100%</td></tr>
</table>

Source: Case study analysis compilation

Source: Case study analysis compilation

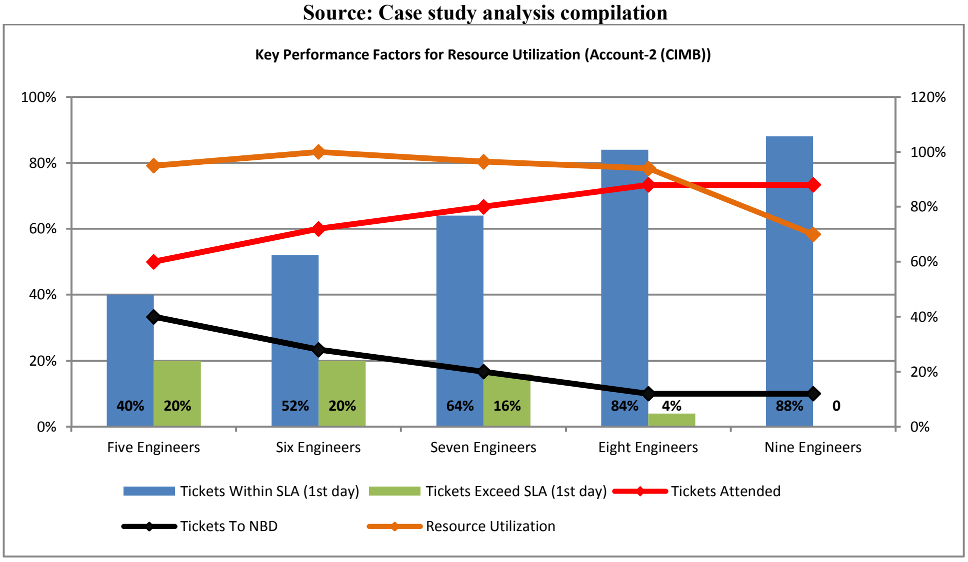


Figure 92 Account-2: Key Performance Factors for Resource Utilization

Figure 92 summarized the key performance factor of "Tickets Within SLAs", "Tickets Exceed SLAs", "Total Tickets Attended", "Total Tickets to NBD (Next Business Day)" and "Resource Utilization". The result revealed that there exists a relationship between "Number of Engineer" with the five key performance factors. As the number of dedicated engineers assigned to Account-2 increases:

- More tickets are attended within the first day and fewer tickets are brought forward to the next-business-day.
- More tickets are resolved within first day or fewer tickets violated the SLAs.
- Engineer utilization is fully maximized (100% utilization) when six dedicated engineers are assigned to the simulation. Thereafter, engineer utilization appeared a slow dropped from the category of seven, eight and nine engineers, recording 96.4%, 93.75% and 69.4% engineer utilization respectively.

Source: Case study analysis compilation

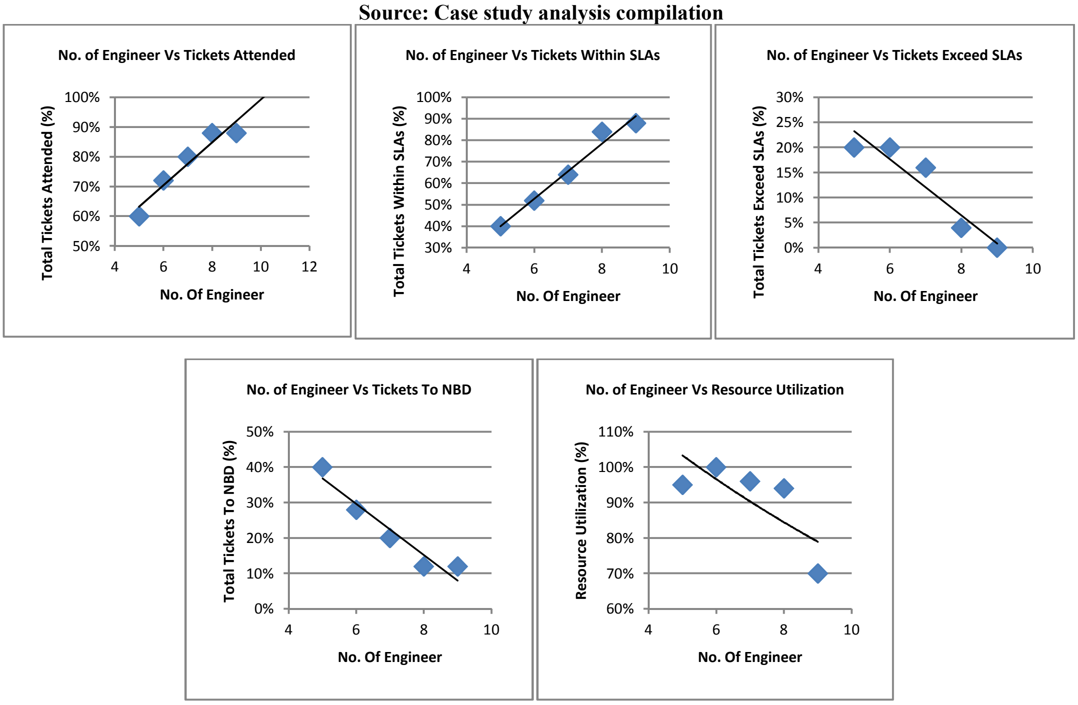


Figure 93 Account-2: Relationship between Key Performance Factors

Therefore, the following relationship between numbers of dedicated engineers assigned and respective key performance factors are proposed in Table 102:

Table 102 Company-C: Key Performance Factors Relationship

Process	Variables	Relationship
Positive	• **"Number of Engineer"** • **"Total Tickets Attended"**	The more dedicated and experienced engineers assigned to Account-2, the more tickets will be attended within the same day
	• **"Number of Engineer"** • **"Total Tickets within SLAs"**	Greater number of dedicated and experienced engineers assigned to Account-2, gives higher reported tickets resolved within SLAs and lesser tickets violate SLAs (Negative relationship with "Total Tickets Exceed SLAs")
Negative	• **"Number of Engineer"** • **"Total Tickets to NBD"**	The more number of dedicated and experienced engineers being assigned to Account-2, lower number of tickets will be pushed to next business day.
	• **"Number of Engineer"** • **"Resource Utilization"**	The more number of dedicated and experienced engineers are assigned to Account-2, the weaker it is in engineer utilization after the optimum point.

Source: Case study analysis compilation

In summary, as the number of engineer increases, more tickets are attended within the same day and more tickets are reported with conformance to SLAs and fewer tickets are needed to be brought forward to next business day; resulting in a more effective and efficient engineer utilization. With an average of 25 tickets per day, engineer utilization is optimized with six engineers' assignment. The simulation with more than six engineer assignment showed a drop in resource utilization where engineers are gradually reported not being fully optimized.

Figure 93 clearly outlined the positive and negative relationships between "number of engineers" against "total tickets attended", "total tickets within SLAs", "total tickets to NBD" and "resource utilization". It is important to strike a balance between these key performance factors in order to reach maximum capacity.

The series of data collection and data analysis performed on Account-2 has proven that **SLAs violation is a result of sharing the same pool of engineers among different project accounts with different resolution SLAs duration which leads to prolonged communication/coordination time and further jeopardizing the achievement of resolution SLAs**. Therefore, the root-cause approach the research team undertakes should target these key performance factors which proven to have major impact (either directly or indirectly) towards the case company's SLAs performance.

The research team posted and grouped the investigation into two broad categories of output measures and input/output process measures. The summarized root causes hypothesis for the case company are:

- Sharing of engineers within same pool of available resources can reach maximum resource utilization only if attended tickets are from the "same SLAs resolution duration".
- The negative relationship of "number of engineer" and "resource utilization" after optimum point is the main concern the case study company is facing which affect its SLAs performance.

- The positive relationship of "number of engineer" with "total tickets attended" and "total tickets within SLAs" is the core rules for better achievement in SLAs performance but one needed to consider "resource utilization" as it contributes to cost overrun.

The primary goal is to improve SLAs performance with dedicated engineers assigned to Account-2 where optimum resource utilization is met so as to keep operational cost at minimum. Since all the vendor-client accounts are running simultaneously over the years with the same pool of engineers, no significant effort has been taken to investigate the root-cause and there is no predetermined solution for the challenges.

Table 101, Table 103, Figure 92 and Figure 93 showed increasing resource utilization when five or six dedicated engineers are assigned to serve single project account. Resource utilization reaches an optimum peak of 100% when six dedicated engineers are assigned to attend the maximum number of tickets per day. As a result, 18 tickets (i.e. 72%) are attended within the same day with 7 tickets needed to be brought forward to next business day. Only 13 tickets (52%) are simulated within SLA performance.

When more engineers are added to the pool of dedicated engineers after optimum point has reached, more tickets are attended (80% for seven engineers, 88% for eight engineers) and the SLA performance improves significantly from 64% to 84% with the option of seven dedicated engineers and eight dedicated engineers respectively. When the number of engineers continued increased to nine engineers, improvement in number of tickets attended and SLA performance continues to excel and number of tickets brought over to next business day reduces proportionally. Although further increase in the number of engineers return better SLA performance but the engineer utilization deteriorate significantly from to 69.4% (i.e. only about 50% utilization rate). The immediate impact of this scenario will result an increase in operational cost as more engineers are needed to be employed and to be on standby to attend tickets with relatively short SLA resolution time.

Table 103 Account-2: Resource Utilization Simulation for Five dedicated Engineer (Account-2, Bank-C)

<u>Option 1 : Based – FIVE (5) dedicated engineers serving Account-2 (Bank-C) only</u>

Assumption:

- Coordination/Communication Time =1.0 hr ;
- Engineer On-Site Time = 1.5 hr ;

Outcome :	Resource Utilization
• Total Ticket = 25 • Total Ticket Attended = 14 (56%) • Within SLA = 10 Tickets (40%) • Exceed SLA = 5 Tickets (20%) • NBD Ticket = 11 Tickets (44%)	• Engineer #1 – (2.0 hr) – 75% • Engineer #2 – (2.5 hr) – 100% • Engineer #3 – (2.5 hr) – 100% • Engineer #4 – (2.5 hr) – 100% • Engineer #5 – (3.0 hr) – 100%

No	Ticket	Time-In	Time-Expire	Engineer in KL Region	09:00 – 10:00	10:00 – 11:00	11:00 – 12:00	12:00 – 1:00	1:00 – 2:00	2:00 – 3:00	3:00 – 4:00	4:00 – 5:00	5:00 – 6:00
1	Ticket-A	3/6/13 09:09	3/6/13 13:09	**Eng-#1 (2.0hr)**	**Ticket-A (Within SLA)**		**Ticket-F (Within SLA)**		**Ticket-K (Exceed SLA)**				
2	Ticket-B	3/6/13 09:48	3/6/13 13:48	**Eng-#2 (2.5 hr)**	**Ticket-B (Within SLA)**			**Ticket-G (Within SLA)**		**Ticket-L (Exceed SLA)**			
3	Ticket-C	3/6/13 09:47	3/6/13 13:47	**Eng-#3 (2.5 hr)**	**Ticket-C (Within SLA)**			**Ticket-H (Within SLA)**		**Ticket-M (Exceed SLA)**			
4	Ticket-D	3/6/13 09:47	3/6/13 13:47	**Eng-#4 (2.5 hr)**	**Ticket-D (Within SLA)**			**Ticket-I (Within SLA)**		**Ticket-N (Exceed SLA)**			
5	Ticket-E	3/6/13 09:57	3/6/13 13:57	**Eng-#5 (3.0 hr)**		**Ticket-E (Within SLA)**		**Ticket-J (Within SLA)**					
6	Ticket-F	3/6/13 09:57	3/6/13 13:57										
7	Ticket-G	3/6/13 09:54	3/6/13 13:54										
8	Ticket-H	3/6/13 10:28	3/6/13 14:28										
9	Ticket-I	3/6/13 10:36	3/6/13 14:36										
10	Ticket-J	3/6/13 10:36	3/6/13 14:36										
11	Ticket-K	3/6/13 10:56	3/6/13 14:56										
12	Ticket-L	3/6/13 11:05	3/6/13 15:05										
13	Ticket-M	3/6/13 11:10	3/6/13 15:10										
14	Ticket-N	3/6/13 11:22	3/6/13 15:22										
15	Ticket-O	3/6/13 11:17	3/6/13 15:17										
16	Ticket-P	3/6/13 11:32	3/6/13 15:32										
17	Ticket-Q	3/6/13 11:54	3/6/13 15:54										
18	Ticket-R	3/6/13 12:43	3/6/13 16:43										
19	Ticket-S	3/6/13 14:08	4/6/13 10:08										
20	Ticket-T	3/6/13 14:33	4/6/13 10:33										
21	Ticket-U	3/6/13 14:46	4/6/13 10:46										
22	Ticket-V	3/6/13 15:26	4/6/13 11:26										
23	Ticket-W	3/6/13 16:52	4/6/13 12:52										
24	Ticket-X	3/6/13 15:40	4/6/13 12:40										
25	Ticket-Y	3/6/13 15:40	4/6/13 12:40										

Source: Case study analysis compilation

7.5 Improve Phase

7.5.1 Introduction

Upon completing the Analysis phase, a list of possible actions and ideas addressing the root causes was compiled from both the Analysis and Measure phases are outlined in Table 104. These possible suggestions and guidelines were shared with the operation manager on 24th Oct 2013 where suggestions for improvement was proposed into two broad categories: (1) Assign dedicated engineers to Account-2; (2) Suggestions to improve the efficiency and effectiveness of operational flow of ticket-engineer assignment by better resource managing, controlling and allocating among the dedicated pool of engineers.

Table 104 Account-2: Proposal of Action Plan

	Actions	Responsible
1.	Improve SLAs performance by adopting dedicated engineers into Account-2 for KL region only	• Operation Manager • Helpdesk Support Staff • Engineer
2.	Improve, manage, control and track SLAs performance by using a prediction chart (KL region)	• Operation Manager
3.	Broadening the awareness of culture change by recognizing the importance of engineer performing on-time ticket closure	• Helpdesk Support Staff • Engineer
4.	Improve efficiency of ticket closure by introducing performance incentive for on-time ticket closure	• Helpdesk Support Staff • Engineer
5.	Introducing SLA Expiry Time Chart to ease of SLA Expire computation with high level of accuracy	• Helpdesk Support Staff • Operation Manager

Source: Case study analysis compilation

7.5.2 Improvement Action Plan (AP)

7.5.2.1 AP#1: Adopting Dedicated Engineers

Table 101 and Figure 92 tabulated an increasing of resource utilization when five or six dedicated engineers are assigned to a serve a single project account. Resource utilization reaches an optimum peak of 100% resource utilization when six dedicated engineers are assigned to attend a maximum number of tickets per day. As a result, 18 tickets (i.e. 72%) are attended within the same day with 7 tickets needed to bring forward to next business day. Only 13 tickets (52%) are simulated within SLA performance.

As discussed in the earlier section, there is always an optimum point (i.e. in this case is eight dedicated engineers) where SLA performance is at its maximum capacity and least tickets are brought forward to NBD. Although putting extra dedicated engineers will continue to excel in SLA performance, but the engineer utilization deteriorate significantly to 69.4% with 33% of the engineer being underutilized. In long term, operating cost is expected to increase with better SLA performance but lower engineer utilization. It is important to strike a balance between revenue and expenditure in order to achieve maximum in ROI.

Ever since the start of Account-2 implementation in Jan 2012, the case company is unable to predict the ticket volume for current month as well as month-to-be. The revenue costing for Account-2 is based on the total attended ticket volume claims. Therefore, it is a common practice for the case company to take in as many tickets as possible from the vendor; manage the severity level and track the SLA performance within pool of available helpdesk staff and engineers. Due to the nature of this unpredictable ticket volume, the case company always resides in a “reactive” mode and encountered challenges when dealing with SLA performance.

If the case company can effectively and efficiently assign relevant number of dedicated engineers to attend to the forecast ticket volume, the tickets will be better managed, controlled and tracked; at least at a noticeable and manageable improvement level in SLA performance with optimum resource utilization without much overrun in operating cost. It is important for the case company to strike a balance between SLA performance, engineer utilization and operational cost. Besides, the outcome of dedicated engineers adoption has been proven earlier by a “FTE simulation with dedicated engineer (Table 99)” using historical data as well as trend chart (Figure 93) of past data. Both the tables of “summary of dedicated FTE simulation” (Table 100) and “FTE vs SLAs Violation” have proven “Dedicated Engineers” being the major contributors to SLAs performance. However, the approach of creation of a prediction chart is necessary to close the gap of SLA performance and at the same time optimizes the resource utilization.

7.5.2.2 AP#2: Prediction Chart of SLA Performance and Resource Utilization

The outcomes of data collection from the historical data of Account-2 for the month of April, May and June has enabled the research team to extend the analysis into prediction of SLA performance and engineer utilization with forecasted ticket volume. The prediction chart aims to provide an inexpensive and cost-effective approach to pre-allocate an optimum number of dedicated engineers to attend *x*-number of projected tickets and achieve optimization in the percentage SLA performance and resource utilization. This is to keep lowest possible operation cost while at the same time achieve an improvement in SLAs performance; as well as being efficient and effective in utilizing dedicated engineers. Table 105 depicts is a prediction chart for both SLAs performance and engineer utilization based on projected ticket volume and number of dedicated engineers assigned to Account-2 for KL region only. The prediction chart was created based on a set of assumptions:

- Estimation is based on KL region only with full-time dedicated engineer(s) serving Account-2 only.
- This prediction chart may not be suitable for other regions due to differences in geographical coverage across regions.
- FTE utilization is based on 20 working days a month, 3 tickets per engineer per day.
- The SLA benchmarking estimates uses the month-based historical data from April, May and June, 2013.

Table 105 Account-2: Prediction Chart of SLAs Performance and Engineer Utilization

Total Ticket	No. of Engineer	Within SLA (%)	Exceed SLA (%)	Engineer Per Ticket Per Month	FTE Utilization
200 - 250	2	13% - 28%	73% - 88%	5.00 - 6.25	135% - 210%
	3	23% - 38%	63% - 78%	3.33 - 4.17	100% - 140%
	4	33% - 48%	53% - 68%	2.50 - 3.13	80% - 105%
	5	43% - 58%	43% - 58%	2.00 - 2.50	65% - 85%
	6	53% - 68%	33% - 48%	1.67 - 2.08	55% - 70%
	7	63% - 78%	23% - 38%	1.43 - 1.79	45% - 60%
250 - 300	3	18% - 33%	68% 83%	4.17 - 5.00	125% - 170%
	4	28% - 43%	58% - 73%	3.13 - 3.75	100% - 130%
	5	38% - 53%	48% - 63%	2.50 - 3.00	80% - 105%
	6	48% - 63%	38% - 53%	2.08 - 2.50	65% - 85%
	7	58% - 73%	28% - 43%	1.79 - 2.14	60% - 75%
	8	68% - 83%	18% - 33%	1.56 - 1.88	50% - 65%
300 - 350	3	13% - 28%	73% 88%	5.00 - 5.83	145% - 200%
	4	23% - 38%	63% - 78%	3.75 - 4.38	115% - 150%
	5	33% - 48%	53% - 68%	3.00 - 3.50	95% - 120%
	6	43% - 58%	43% - 58%	2.50 - 2.92	80% - 100%
	7	53% - 68%	33% - 48%	2.14 - 2.50	70% - 85%
	8	63% - 78%	23% - 38%	1.88 - 2.19	60% - 75%
	9	73% - 88%	13% - 28%	1.67 - 1.94	55% - 70%
350 - 400	3	8% - 23%	78% 93%	5.83 - 6.67	165% - 225%
	4	18% - 33%	68% - 83%	4.38 - 5.00	130% - 170%
	5	28% - 43%	58% - 73%	3.50 - 4.00	115% - 135%
	6	38% - 53%	48% - 63%	2.92 - 3.33	95% - 120%
	7	48% - 63%	38% - 53%	2.50 - 2.86	80% - 100%
	8	58% - 73%	28% - 43%	2.19 - 2.50	70% - 85%
	9	68% - 83%	18% - 33%	1.94 - 2.22	60% - 75%

Indicates Optimum Point of Engineer Utilization

Source: Case study analysis compilation

In view of the reliability and creditability of the prediction chart for Account-2 (KL region), it is important to validate and verify the prediction chart against live data. A set of compiled life data from July 2013 till January 2014 (i.e. seven months of data validation); adopting the approach of dedicated engineers was tabulated, validated and verified in Table 106.

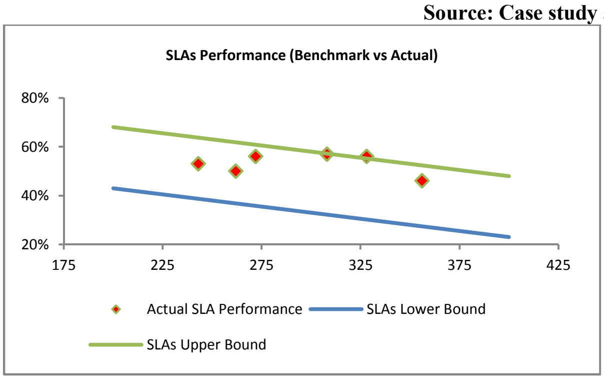
The actual result of SLAs performance and FTE Utilization was plotted into Figure 94. It can be noticed that both the actual performance are indeed fell within the upper and lower boundary defined in the prediction chart. This proved that the prediction chart created using historical data from Account-2 can be used to benchmark future prediction of SLAs performance, FTE utilization and most importantly the ability to assist and gauge the operational team with strong fundamentals of operational cost analysis when drafting and negotiating new rounds of service level agreements. This approach in general is applicable especially to those project accounts where SLAs duration is relatively short (i.e. between 2-4 hours for Account-2) and conformance to SLAs performance is challenging and costly. These challenges of deciding how costly an operating cost would be to achieve desirable SLAs when drafting an outsourcing contract is important for continuous cost-benefits analysis.

Table 106 Account-2: Benchmark Data Validation (KL Region Only)

Month	SLA Performance								Resource Utilization			
	Exceed SLA		Within SLA		Total	Actual	Within SLA		No of FTE	FTE Utilization		
	Qty	%	Qty	%			Benchmark	Result		Actual	Benchmark	Result
Jul-13	191	54%	165	46%	**356**	46%	**33% - 48%**	√	5	100%	95% - 120%	√
Aug-13	120	44%	152	56%	**272**	56%	**48% - 63%**	√	6	78%	65% - 85%	√
Sep-13	133	43%	175	57%	**308**	57%	**43% - 58%**	√	6	86%	80% - 100%	√
Oct-13	132	50%	130	50%	**262**	50%	**48% - 63%**	√	6	76%	65% - 85%	√
Nov-13	143	44%	185	56%	**328**	56%	**43% - 58%**	√	6	88%	80% - 100%	√
Dec-13	113	47%	130	53%	**243**	53%	**38% - 53%**	√	5	72%	65% - 85%	√
Jan-14	112	36%	198	64%	**310**	64%	**58% - 73%**	√	7	73%	70% - 85%	√

Source: Case study analysis compilation

Source: Case study analysis compilation



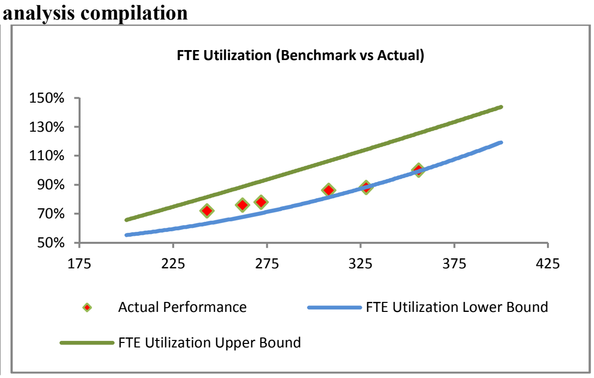


Figure 94 Account-2: Benchmark vs Actual (SLAs Performance and FTE Utilization)

7.5.2.3 AP#3: Broadening Awareness of "On-time Ticket Closure"

It is important to raise the awareness of individual engineers' understanding of the importance of on-time ticket closure for every logged ticket. The aim is to broaden the awareness of work culture change amongst the pool of engineers by recognizing the urgent need to perform ticket closure before attending to the next ticket. The resolution time starts ticking when a ticket is logged and stops when the vendor's helpdesk staff receives ticket closure from case company. There are two modes of ticket closure; submission of scanned jobsheet and update jobsheet details into email reply to vendor's helpdesk system.

The current Incident Service Cycle is outlined in Figure 95. The dotted line rectangle is an important activity which has been conveniently neglected by most engineers. The incident service cycle clearly outlines that engineer ticket closure is one of the key milestones in the SLAs performance, however it has been deliberately overlooked by engineers as ticket closure is seen to be the responsibility of the helpdesk executive. Most engineers were unaware that there are two different types of ticket closure, which is "closure by engineer" and "closure by helpdesk executive". Upon completion of ticket resolution, engineers are require to send the scanned copy of Jobsheet or contact the call center to provide updates on resolution details so as the ticket can be closed by any helpdesk executive.

Helpdesk executive alone is not capable of performing ticket closure unless he/she is provided with resolution details from assigned engineers. In the event the engineer performs ticket closure, ticket closure by helpdesk executive is not needed. Currently, most engineers are leaving the last milestone responsibility of ‘engineer ticket closure” to helpdesk executive where significant redundant and overlapping effort is required to ensure on-time ticket closure to meet SLAs performance.

Source: Case study analysis compilation

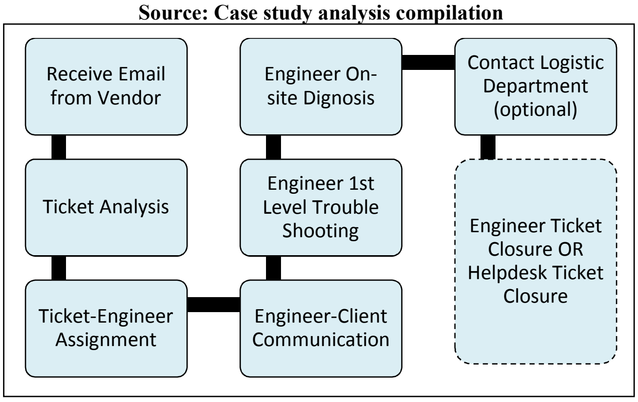


Figure 95 Account-2: Incident Service Cycle

The root cause of engineer’s tendency to delay on-time ticket closure is the unavailability of IT gadgets (i.e. smart phone which allowed internet connection on-the-go) and Telco data plan which deters engineer from real-time uploading of scanned jobsheet to the helpdesk system. At the same time, due to minimum resolution time buffer from an assigned ticket to the next in-line ticket, engineers are always in a rush to attend to the next assigned ticket and conveniently transfer the responsibility of ticket closure to the helpdesk executive.

Hence, it is important to raise awareness amongst engineers in completing the incidents service cycle without skipping any steps. Only the assigned engineer himself/herself knows best when the ticket is resolved and calls for ticket closure. If the engineer can take up the responsibility to initiate ticket closure upon completion of ticket resolution, the resolution time can be shortened and no follow up effort is required. Thus, management support and positive awareness amongst engineers is crucial to cultivate culture change in on-time ticket closure for the benefits of SLAs achievement. As such, ticket closure can be carried out effortlessly in a timely manner in reach of better SLAs performance achievement.

7.5.2.4 AP#4: Introducing Performance Incentive for On-time Ticket Closure

As discussed in the earlier section, the resolution time will be ticked off only when the assigned ticket is closed in the vendor’s helpdesk system. On-site resolution by engineer does not grant any permission to ticket closure unless there is an accompanying scanned jobsheet or resolution details are updated into vendor’s helpdesk system.

It is widely recognized that any matters pertaining to human factors and work culture takes time to observe positive changes in place. Therefore, it is important to give the pool of engineers' specific goals to work toward to, supported by significant rewards. The team is proposing on-time-ticket-closure incentive to motivate and recognize individual engineer's accomplishment of completing the incident service cycle soonest possible in meeting the SLAs.

Since the existing operational activities already have all tickets tracked and monitored with engineer assigned as well as time when a ticket is resolved. The incentive program will required the helpdesk executive to track numbers of tickets solved within SLAs limits by the respective individual engineer. Engineers with most tickets resolved within SLAs (or least SLAs violation) will be granted with an incentive. The aim is to motivate engineers to perform on-time ticket closure upon ticket resolution.

7.5.2.5 AP#5: Introducing SLA Expiry Time Chart

It is important to raise awareness with the helpdesk team for the need to calculate the SLA expiry time in order for accurate SLA performance monitoring and tracking. Although initiatives of SLA expiry computation can be observed in the month of May and June, only partial tickets had SLA expiry time calculated (i.e. 63% and 57% for May and June respectively) as outlined in Table 107. The root cause of the helpdesk executive not computing the SLA expiry time is due to complexity of the calculation as Account-2 is not a 24/7 account. Account-2 is an account following official working hour from 9:00 am till 5:00 pm for Monday till Friday and engineers are off on weekend. Extra attention and effort from the helpdesk team is required when performing the computation of SLA expiry time, needing to take consideration into official "working hours (i.e. 9 am to 5 pm) and working day (i.e. Monday to Friday) only.

Table 107 Account-2: SLA Expire and SLA Correctness

Month	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	June 2013	July 2013	Aug 2013	Sep 2013	Oct 2013	Nov 2013	Dec 2013	Jan 2014
Region-KL	160	156	223	317	273	269	356	272	308	262	328	243	310
SLA Expire Computation Calculated	0%	0%	0%	0%	63%	57%	100%	100%	100%	100%	100%	100%	100%
SLA Expire Correctness Computation	N/A	N/A	N/A	N/A	40%	62%	67%	69%	67%	64%	65%	78%	84%

Source: Case study analysis compilation

Due to these reasons, the accuracy of SLA expiry computations are often recorded not at a satisfactory level with May reported to have 40% accuracy only in SLA expiry time computation. An SLA expiry time chart was introduced to ease of helpdesk executive in computing the SLA expire time. The chart lists down all possible ticket time-in times (working hour as well as off working hour) and the corresponding expected SLA expiry time. Special and careful attention is needed when computing the expiry time as it is based on working hours and working days.

The chart was created (i.e. Appendix-2) and ready for usage for the month of Nov 2013. It is a benchmark chart which allows mapping of expiry time when "Day of the week (e.g. Monday or Tuesday)" and "Ticket-Time-In" are provided. This guided chart aims to shorten the manual SLA expiry computation time as well as increase the correctness and reliability of computed SLA expiry time. The positive culture changed of SLA computation can be seen in the month of June 2013 till Jan 2014 where all tickets are mandated with SLA expiry time computed. Ever since the chart was put into implementation by the helpdesk executive since Nov 2013 till Jan 2014, the accuracy of SLA expiry computation has improved gradually from 65% to 78% and latest achievement recorded at 84% in the month of Jan 2014. The guided chart can be viewed at Appendix-2.

An improvement of 23.8% in SLA expire time computation is reported for Oct 2013 and Jan 2014 where both helpdesk executive and engineers are confident in the accuracy of the computed SLA expiry time during the tracking, monitoring and managing ticket assignment and ticket closure in the outsourcing process. The month of Oct 2013 and Jan 2014 were recorded with 1.86-sigma and 2.49-sigma level respectively. The improvement of 25.3% in sigma level proved that the SLA Expire Time Chart is effective in assisting the helpdesk executive to provide greater accuracy in SLA expiry time. The usage of SLA expiry chart further shortened the communication/coordination time in the ticket-engineer assignment which in turn allows more buffer time in resolving tickets closure.

7.5.3 Six Sigma Implementation Outcomes

The Six Sigma DMAIC approach allowed the research team to analyze the root cause of SLA violations due to the issue that engineers from the same pool of resources are assigned to all project accounts with different SLAs durations. The outcomes from the Account-2 historical data enabled the research team to extend the analysis into prediction of SLA performance and engineer utilization with forecasted ticket volume.

As a result, the case company can effectively and efficiently assign relevant number of dedicated engineers to attend to the forecasted ticket volume, the tickets could be better managed, controlled and tracked; at least at a noticeable and manageable improvement to SLA performance with optimum resource utilization and without much overrun in operating cost. The outcome of the prediction chart has raised awareness among the management team that the "optimum point" of resource utilization has significant impact in SLAs performance, resource utilization and operational cost. These trio-fact findings have proven to be useful and relevant to the management team for future contract negotiation and drafting of SLA contract.

Thus, the culture of SLA expiry time computation as part of the operational policy and procedure has been carried out successfully with consistent reporting of 100% in SLA expiry time computation from the month of July 2013 to January 2014 as opposed to none in Jan, Feb and March 2013. The omission of SLA expiry time calculation has deterred the helpdesk team in managing, tracking and monitoring the SLA performance for Account-2 which is deemed unavailable as shown in Table 108.

With the assistance and guidance from the prediction chart of SLA and resource utilization, the operational manager is capable of carrying out advanced planning in assigning dedicated resources with the ability to forecast forthcoming months' tickets activity and forecast SLA performance achievement in return of optimizing resource utilization and maximizing SLA performance. Prior to the usage of the prediction chart, Account-2 required eight FTE in handling 223 tickets (i.e. Mar 2013) and FTE utilization is 43%. The adoption of the prediction chart assisted the management team to assign fewer engineers (i.e. five engineers) in handling more tickets (i.e. 243 tickets in Dec 2013) and achievement of better FTE utilization (i.e. 72%). The SLA performance improved 28% from Oct 2013 compare with Jan 2014 where an improvement of 19% in sigma-level was reported. (i.e. 1.5σ in Oct 2013 and 1.858σ in Jan 2014). Through Six Sigma implementation in operational improvements, Company-C was reported with cost saving of 37.5% on operating cost per month (i.e. three FTEs) with fewer dedicated engineers (i.e. better FTE utilization by 41%) and lesser SLA violations (i.e. 36%).

Table 108 Account-2 Six Sigma Post Implementation Achievement

	HISTORY DATA BENCHMARKING (PHASE-I)			HISTORY DATA BENCHMARKING (PHASE-II)				SIX SIGMA IMPLEMENTATION		
Month	Jan 2013	Feb 2013	Mar 2013	July 2013	Aug 2013	Sep 2013	Oct 2013	Nov 2013	Dec 2013	Jan 2014
Region-KL	160	156	223	356	272	308	262	328	243	310
FTE-KL	8	8	8	5	6	6	6	6	5	7
SLA Violation-KL	N/A	N/A	N/A	54%	44%	43%	50%	44%	47%	36%
SLA Violation-ALL Region	N/A	N/A	N/A	55%	59%	48%	50%	53%	49%	42%
FTE Utilization	33%	31%	43%	100%	78%	86%	76%	88%	72%	73%
SLA Expire Correctness Computation (All Region)	N/A	N/A	N/A	67%	69%	67%	64%	65%	78%	84%
SLA Expire Computation	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%

Source: Case study analysis compilation

7.6 Chapter Summary

The improvement strategies as a result of Six Sigma DMAI-C initiative has raised awareness among the operational and managements team regarding the necessity of assigning different pool of engineers to project accounts with different SLAs resolution/response expiry duration. Sharing the same pool of expertise across project accounts with various SLAs expectations complicates the ticket-to-engineer assignment task and further jeopardizes respective engineer's effectiveness and efficiency in tickets handling which further result delays in ticket-closure.

Furthermore, the formulation of a prediction chart of SLA performance against number of dedicated engineers versus FTE utilization allows the operation manager to deal confidently and comfortably in forecasting ticket volumes and SLA performance in cope of optimum engineers utilization and greater SLA performance.

The combination improvement efforts of adopting dedicated engineers within similar SLAs resolution/response duration expires and formation of a prediction chart (i.e. SLA performance vs number of engineers and FTE utilization) has resultant lower operating cost and better engineer utilization achievement and SLA performance. In short, the Six Sigma initiatives implemented at Company-C has explored another dimension of improvement in the business area of IT Service and IT Process.

Chapter 8 Synthesis Summary

8.1 A Review of Quality Relationships

8.1.1 Introduction

Producing IT products and IT services requires careful design. The IT development process is intangible and labour intensive. Making optimal use of available resources, both soft (knowledge, skill-set etc.) and hard (computer system, ancillary equipment etc.) skills, is vital if IT development is to achieve sensible economic advantages.

Over the years, there has been rapid expansion of the IT role from simply assisting and supporting business activities to managing and controlling IT related processes. The maturity of an IT process greatly depends on how accurately the process is defined, measured and controlled [58]. Much attention is given to IT processes, which are often used as a measurement indicator of a company's maturity level and quality management. In order to prepare IT companies striving to achieve highly matured processes with the aim of producing acceptable and high quality outputs, it is important to review the relationship between two major areas of concern: (1) Integration of IT Products and IT Services within an existing IT Process architecture and; (2) How IT Products and IT Services are built into the framework of Product Life Cycle, Project Life Cycle and System Development Life Cycle (SDLC).

8.1.2 Literature Review

There are many publications [14, 113, 120, 124, 127, 260] where the authors of Hoerl, Brice, Antony, Thomerson, Hoffer et al., and Dennis et al., had attempted to establish the relationship of Product Life Cycle, Project Life Cycle and SDLC. However, most of these papers focus on two cycles and neglect the other one, i.e. the relationship between Project Life Cycle and SDLC are openly discussed, quoted and adopted by many researchers and companies; and at the same time it is being published and shared as teaching resources [14, 113, 120, 124, 127, 260] among university instructors. This relationship between Project Life Cycle and SDLC has become a fundamental and compulsory topic for every IT-related course.

Apart from the traditional view of SDLC within its project life cycle, there is an urgent need to establish a general yet widely acceptable guideline on the most effective and efficient way to precede an IT project in the broader view of Product Life Cycle. Handling of product quality should be viewed from the product life cycle perspective and not limited to the production stage alone, i.e. Project Life Cycle and SDLC. After all, problems arise from customer complaints and customer dissatisfaction will eventually affect the delivery status and jeopardize company reputation.

8.1.3 Definition of Terms

IT Process is a sequence of interdependent and linked procedures; which at every stage consumes one or more resources (employee time, effort, knowledge, expertise, energy, machines, money etc.) to convert inputs (data, material, parts, etc.) into outputs. These outputs then serve as inputs for the next stage depending on business nature until a known goal or end result is reached. In IT project management, hardware and software are the two main components of *IT Product* deliverables.

The term computer *hardware* is best described as all the physical parts of your computer and related devices, or the parts you can feel and touch. Software consists of carefully-organized instructions and codes written by programmers in any of the various special computer languages and may come in several forms: single programs like script interpreters, packages containing a compiler, linker, and other tools; and large suites.

Software is often broken into two major categories: system software and application software. System software is responsible for controlling, integrating, and managing the individual hardware components of a computer system so that other software and the users of the system see it as a functional unit without having to be concerned with the low-level details. Application software handles multitudes of common and specialized tasks a user wants to perform, such as accounting, communicating, data processing, word processing etc.

IT Services is a set of IT business strategy solutions and a systematic methodology which leads to breakthrough in profitability through quantum gains in service quality, customer satisfaction and productivity. The key philosophy for IT Services Management is to continuously reduce faults, delays and variation in service processes with the aim to reduce customer dissatisfactions, delays, defects or failure from every product, service and transactional process [260].

Systems Development Life Cycle (SDLC) is a framework describing the phases involved in developing information systems [124, 127, 261]. SDLC is a conceptual model used in project management that describes the stages involved in an information system development project, from an initial feasibility study through maintenance of the completed application. The primary objectives of SDLC are to ensure high quality systems are delivered, provide strong management controls over the projects, and maximize the productivity of the systems staff [30, 124]. In the first *Planning* phase, an organization's information needs are examined as a whole where project needs are prioritized and translated into a plan; followed by an *Analysis* phase, where requirements study and requirements restructuring are performed; a *Design* phase where analysts convert the description of the recommended alternative solutions into logical and then physical system specifications; and at *Implementation* phase; where analysts convert system specifications and documentation into a working system that is tested and then put into use; and lastly a *Maintenance* phase, where programmers make changes based on users' feedback and modify the systems to reflect changing business conditions.

The *Project Life Cycle* refers to a logical sequence of activities to accomplish the project's goals or objectives [31]. Regardless of scope or complexity, any project goes through a series of stages during its life. There is first an *Initiation* or Birth phase, in which the outputs and critical success factors are defined; followed by the *Planning* phase, characterized by breaking down the project into smaller manageable parts or tasks; an *Execution* phase, in which the project plan is executed; a *Monitoring* phase, where actual project activities are benchmark against baseline; and lastly a *Closure* or Exit phase, that marks the completion of the project [30, 31].

The *Product Life Cycle* is a marketing theory cycle or succession of strategies experienced by every product which begins with a product's introduction/initiation, sometimes referenced as research and development, followed by its product development, product adoption, then sustaining and finally market saturation and decline/end-of-life [262]. The Product Life Cycle goes through many phases, involves many professional disciplines, and requires many skills, tools and processes. Product life cycle has to do with the life of a product in the market with respect to both business and commercial costs and sales measures. To say that a product has a life cycle is to assert four things: (1) products have a limited life, (2) product sales pass through distinct stages, each posing different challenges, opportunities, and problems to the seller, (3) profits rise and fall at different stages of product life cycle, and (4) products require different marketing, financial, manufacturing, purchasing, and human resource strategies in each life cycle stage.

8.1.4 The Mapping of Product Life Cycle, Project Life Cycle and SDLC

According to Koppensteiner [262] and InterGlobe Consulting firm [263], the project life cycle has to be applied to the product development phase and the product adaptation phase of the product life cycle. Any product (IT and non-IT) is developed during the product development phase by at least following the project life cycle once. When the product development phase is completed, the product is delivered to the market. A new product is always vulnerable to product competition among existing market segments such as product replacement and product switching; and other threats affecting sales growth of the product as being the new entrant to the market space.

In view of additional market needs and demands, the product requires an adaptation phase where a revised or improved product is delivered to the market. Whether the product is capable of sustaining in the market, it is necessary to find out how big the existing customer base that is actively using the product; and if the customers are ready to use the new product. By doing so, respective resources supporting this product can be shifted to the next in-line product in development. Product review is a crucial checkpoint whenever it moves from one phase to the next. This reviewed outcome will help management gather more information to make relevant decisions for the next phase. When the product reaches the Sustaining stage where sales are declining, this product will come to its' end-of-life if all customers have transferred to the new product.

In project management, a project can be defined both with a Project Life Cycle and an SDLC, during which slightly different activities occur. According to Taylor [264], the Project Life Cycle encompasses all the activities of the project, while the SDLC focuses on realizing the product requirements. In the IT industry, SDLC is commonly used during the development of an IT project, it describes the different stages involved in the project from the drawing board, through to the completion of the project. In the middle of the project life cycle (execution phase), the certainty of completing a project improves when more resources are needed and involved [30, 124]. This is the stage where everyone (tester, programmer, system analyst, project leader, project manager, document writer etc.) is involved and investing effort and time hoping to deliver a quality product. Failure to deliver during this stage results in cost overruns where rework is needed. Since the IT development process is expensive and labour intensive [59], it is always wise to follow a proven structured and systematic approach of SDLC to increase the success rate of product development [61].

The relationship between Product Life Cycle and Project Life Cycle has been discussed by the InterGlobe Consulting firm [263] where respective Project Life Cycles are nested into the Product Development phase as well as Product Adaptation phase. This clearly shows that in a real business environment, all products (IT and non-IT) are mandated to go through product life cycle once and *n*-times of Project Life Cycles and *x*-times SLDCs depending on business needs, user perception and acceptance level of product's quality. In conclusion, the broader view inter-relationship between these three cycles is summarized and represented in Figure 96.

Source: Research analysis compilation

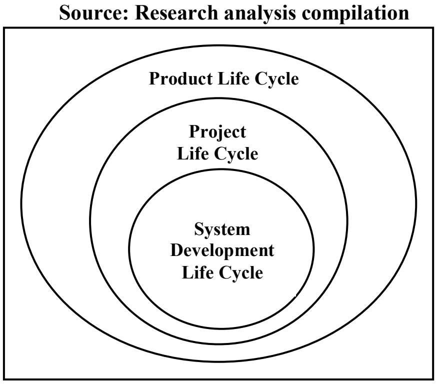


Figure 96 The Relationship Between Product Life Cycle, Project Life Cycle and SDLC [38]

8.1.5 The Relationship between IT Processes, IT Products and IT Services

With today's increasingly competitive economy, IT organizations place great emphasis on operational process management to ensure IT products and IT Services are systematically managed and controlled to achieve better customer satisfaction, better quality, increased revenue growth and employee productivity gains. However, misconceptions arise among management teams being overly focused and emphasizing solely on the output and neglecting the operational processes while developing the product. In many cases, the reviews and discussions of these three IT business areas are always isolated and independent leading to a misunderstanding that these three business areas can be dealt with separately and successfully.

In reality, IT Processes are the heart-of-quality which involves a series of stages/phases transforming and converting input into output. All IT Products and IT Services are mandated to traverse across the stages/phases of IT Process or Product Life Cycle consisting *n*-number of Project Life Cycle and *x*-number of SDLC cycle depending on the business nature. Products can appear in various forms ranging from a good, an idea, a method, information, an object, or service that is the end-result of a process and serves as a need-or-want satisfier. In marketing, a product is anything that can be offered to a market that might satisfy a want or need. In retailing, products are called merchandise. In manufacturing, products are purchased as raw materials and sold as finished goods. In insurance, the policies are considered products offered for sale by the insurance company that created the contract. In investment institutions, customized investment plans are the end products companies offer to their investors. Therefore, an IT "product" need not always be a "machine" related item as it greatly depends on the respective business nature.

In most cases, the development of an IT Product (e.g. customized software) will be seen as "a" project (Project-A) to a project team (e.g. Team-A) where resources, time and effort are spent to deliver the IT Product on time, within budget and adhere to user requirements. Even though the general rule of thumb is to allocate two thirds (66.67%) of total project time for product testing, many project managers are willing to risk and sacrifice product quality by shortening the testing time-frame just to push the end product to the market place and then move on to next project. The popularity of IT services is growing every day, many IT firms and non-IT firms are focusing their efforts on service-oriented processes with the aims of achieving maximum return on investment [15].

As a result, there has been a shift in organizational focus from traditional technology management to service quality and customer relationship management (CRM) [87]. Due to the increasing and endless demand from customers, many IT Products somehow have its product life cycle extended in handling customer requests, complaints, suggestions etc. as a means of CRM.

In general, IT specialists view IT Products and IT Services as a separate entity due to the nature of project management. Many IT Products are pushed to the door to meet product launch-date commitments and project deadline, and thereafter organizations are "forced" to implement IT Services as a mean of "norm" for "after sales service" in collection of user acceptance and product satisfaction due to market pressure in supporting CRM. This approach lacks effort, attention and emphasis given to IT Processes and places tremendous negative impact on the IT product life cycle (i.e. IT Products and IT Services) especially in both the Product Adaptation and Sustaining phases; and at the same time creating threats and challenges to the support teams.

This "after sales service" was seen as a "survival-kit" in this competitive red-sea IT market segment where companies believe in "user acceptability of a product's quality will foster customer loyalty" especially in the long run. In supporting the IT service organization, IT executives and managers are challenged to transform their organization from delivering technology to providing services and ultimately becoming a business partner within the organization [65]. A Helpdesk system, Telephone Assisted Software or TeleClient, Forum etc. are some examples of commonly used CRM medium for most IT Products. These CRM mediums require IT platforms (i.e. any combination of networking, software, hardware etc.) in handling the vast volume of data so that accurate and valuable information can be computed and analyzed in real-time; providing ad-hoc assistance to management in decision making processes as well as future business forecasting.

This CRM medium (i.e. IT Services) will be treated as a new project (Project-B) by another team (e.g. Team-B) which normally goes hand-in-hand from the day the software was launched. In view of different skills set requirement (hard and soft skills) for Project-A and Project-B, resource sharing between Project-A and Project-B are normally kept to a minimum. The input of the CRM medium is actually the software developed earlier by Team-A. If in any circumstance when a portion of the software quality was being risked to meet project deadline by Team-A, it can be foreseen that Team-B will receive many complaints due to customer dissatisfactions as a result of poor quality software. By then when the software was put into use in real-life day-to-day operation, Team-B may have received a long list of reported software bugs with different severity levels (i.e. low, medium and high). If there is any reported high-impact bug(s) causing system halts or disrupting business routine operations, immediate attention is required from both teams (Team-A and Team-B) to plan for a fix-release or a patch-release (i.e. Service pack for Microsoft Product) as part of the project life cycle. This fix-release or patch-release may be treated as a new project (Project-C) again if there are many changes needed to the source code. The same process will go on until a stage when the software reaches the EXIT point where the company decides to prosper with new software.

In short, both the management team and project team should view IT Products and IT Services as *ONE dependent* entity within the product life cycle. This could lead to better controlling, managing and handling of product quality and customer satisfaction. The detailed development activities from IT Products to IT Services or vice versa are in a recursive loop within the boundary of IT Processes as shown in Figure 97.

Source: Research analysis compilation

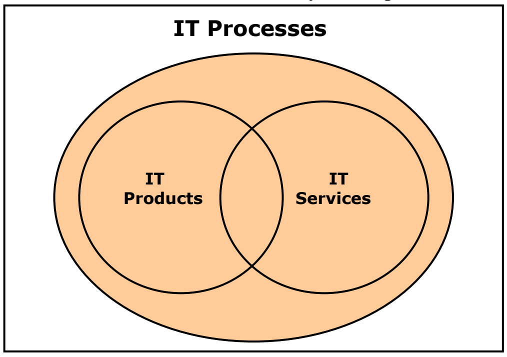


Figure 97 The Relationship Between IT Processes, IT Products and IT Services [38]

8.1.6 The Mapping Relationship between IT Processes, IT Products and IT Services Within Product Life Cycle, Project Life Cycle and SDLC

There exists a strong relationship between IT Process, IT Product and IT Service; and the ability to properly manage one segment (IT Processes) will result in overall performance improvements ranging from output quality, delivery, satisfaction, and sustainable improvement in competitiveness. This means all IT products have a particular life span, which is called the product life cycle. The length of time a product is on the market is largely contingent upon its competition, technology and even the savvy of a company's marketing department. One of the best ways of extending a product's life cycle is to continuously garner feedback from consumers, finding out what they need and want from a particular product.

In order to better illustrate the relationship between IT Process with both IT Products and IT Services, a mapping of their relationship between IT Processes, IT Products and IT Services within the Product Life Cycle, Project Life Cycle and SDLC is proposed in Figure 98. Whether it is IT Products or IT Services, it is necessary for an IT Process stage or phase spanning the entire product life cycle; where an input is transformed into an output. These outputs may also be inputs for other IT business segments further on a later stage. The existence of a relationship between IT Process, IT Products and IT Services does not mean that quality is completely and solely addressed by IT Processes; but the outputs of the IT Product have significant impact on IT Services while further affecting customer expectation and customer satisfaction; and at last impacting the life cycle of the IT Product.

Source: Research analysis compilation

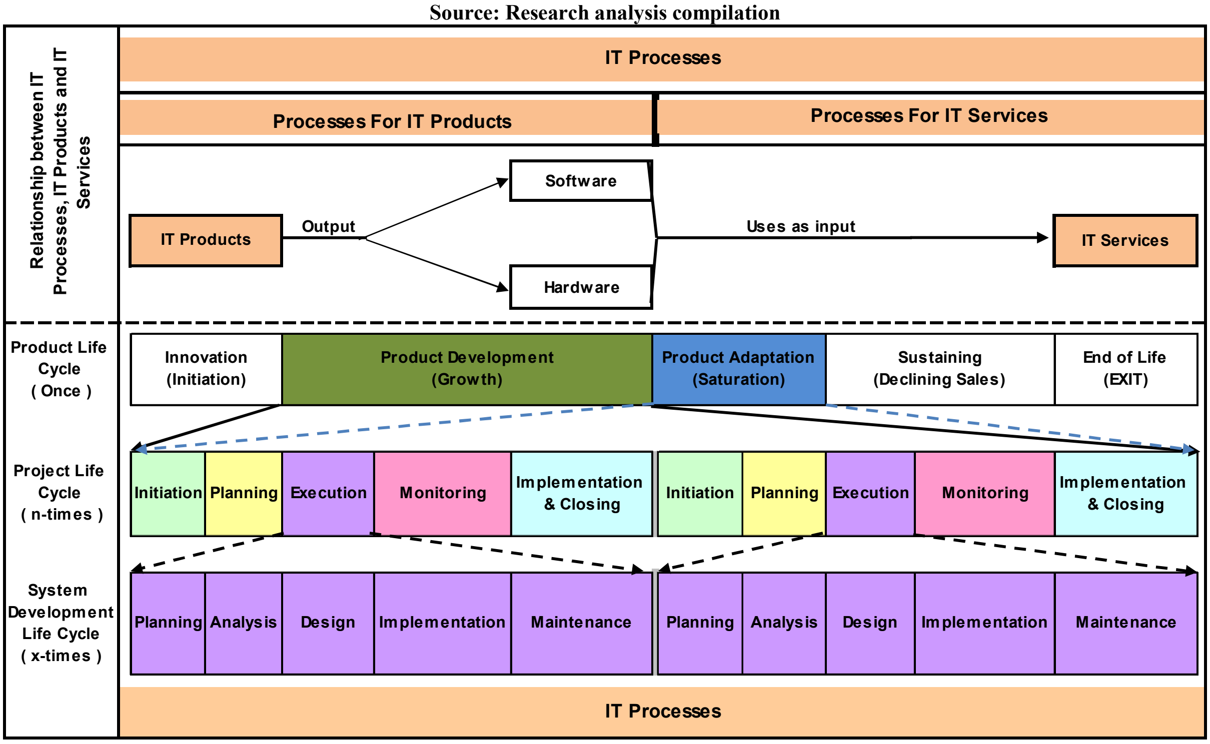


Figure 98 The Mapping Relationship Between IT Processes, IT Products and IT Services Within the Product Life Cycle, Project Life Cycle and SDLC [38]

The reliability of the product has a direct relationship with the way the product is developed. For IT Products and IT Services improvement and maintenance, a higher emphasis should be set to address the IT Process flow which would further strengthen the quality of IT products and IT services. By putting more effort into resource planning and scheduling in the activities of IT Processes where proactive planning is in place could lead to better achievement in quality and understanding of the relationship between IT Products, IT Services and IT Processes to reduce rework which cost 8-10 times more than the original plan [30]. This is the main reason why Vaishnavi [265] views the relationship between IT product structure and product maintainability as an important research issue to be addressed in the near future.

A survey conducted by Hairul et al., [64] has proven a strong linear relationship between high-quality IT development processes and high quality products. Therefore, it is important for IT companies to pay more attention not only in the IT development cycle but also a more general view of IT Products and IT Services within IT Processes in the Product Life Cycle. In particular, the literature and business reviews in IT industry are extremely diversified into three segments; i.e. IT Processes, IT Services and IT Products; with IT Processes dominating the population followed by IT Services and IT Products [266]. Even though these three IT business areas are frequently discussed and reviewed independently, the outcome of each review generally falls into the category of IT Products or IT Services or both as shown in Table 109. Table 109 summarized the adoption of different quality improvement initiatives specifically in the area of IT Processes; which in turn expecting to enhance the quality and consistency of IT Product and IT Service delivery in IT organizations. This can further prove that the ultimate outputs of the IT development process can be categorized into IT Products and IT Services respectively.

Table 109 Adoption of Different QIMs in IT Processes [38]

Title of Literature, Business Review and Brief Explanation	IT Product	IT Service
Using Human Resource Management Suites To Exploit Team Process Improvement Models [267] - This research examines the degree of support of an IT product of Human Resource Management System (HRMS) Suite of Oracle Applications ERP System; on how and to what extent do HRMS applications support organizations to adapt team **process improvement** models for operational routine.	√	
The current state of six sigma application in services [32] - This emerging field of study looking for **process improvement directions** to take the application of Six Sigma (DMAIC) process further in services (IT and non-IT) industry		√
New Research Customer-Centric Six Sigma Quality and Reliability Management [37] - This paper presents a customer-centric Six Sigma quality management as an extension of the traditional Six Sigma way; where the author views **product quality and process reliability** as key to achieving and adopting a holistic view of quality		√
Six Sigma for Service Processes [14] - This paper aims to demonstrates the power of Six Sigma, a **process disciplined approach** to improving product, process or service quality in the IT industry		√
CRM Adoption Success Factor Analysis and Six Sigma DMAIC Application [268] - This paper propose a strategy to integrate Six Sigma DMAIC methodology with the CRM implementation process emphasizing the **critical part of implementation process** as a basis for to provide high possibility of CRM adoption success.		√
Carbon Footprinting of Information Technology Products based on ISO standards (Fujitsu Case Study) [269] - Fujitsu is one of the drivers within the information technology (IT) industry analysed the resulting **Life Cycle Assessment** study of the selected Fujitsu IT products in its PC and server lines, **throughout the process of their product life cycle**. This initiative allows comparable emission calculations which allow helpful insights into the discharge of emissions throughout the complete value chain.	√	
Representation of Knowledge in Information Technology Service Capability Maturity Model (IT Service CMM) [270] - A conceptual modelling language of Conceptual Model Quality Framework (CMQF) is selected and applied to the **IT Process in Service CMM** in order to enable identification of the collaboration requirements of various entities. This in turn is expected to enhance the quality and consistency of service delivery in IT service organizations that utilize the IT Service CMM.		√
Signal Processing and Sys Design of Cylinder Reliability Test for ISO Standard [271] - A study was conducted to analyze the requirement of cylinder reliability test system which involve careful studies in the **signal processing method**, develops solenoid valve drive circuit and the convert circuit and designs cylinder reliability test system. The applications show that the system runs reliably and meet the requirements of the cylinder reliability test.	√	
The Influence Of The Quality Standards IS0 9000 On Telecom Manufacturers [272] - This paper describes how IS0 9000 standards are adopted and implemented in **operational process** of the Public Switching Division of Siemens AG manufacturers and carriers of telecommunications systems operating worldwide with the aim for uniform quality standards.	√	
Software Process Improvement via IS0 9000? Results of two surveys among European software houses [273] - This paper presents and sharing of result outcome of two surveys implemented successfully among European software houses in software process improvement via ISO 9000 as part of the operational activities	√	
Evolution of a Software Maintenance Organization from Cost Center to Service Center [274] - This paper describes the evolution of a software maintenance organization for digital set-top boxes of a leading electronics company from a cost center towards a service center by adopting ITIL service support in the IT process implementation to develop a better customer focused approach for a professional, self-supporting maintenance organization		√

Source: Research analysis compilation

8.1.7 Summary

The quality of IT products is largely governed by the quality of the process used to build it. It is important for engineers, executives and managers to understand the main purposes, advantages and disadvantages of each initiative and how various improvement initiatives can potentially fit together in an integrated approach.

In short, it is crucial to have a deep understanding of how an organization operates or should operate as a system. From the financial viewpoint, it is always important that the product is commercially successful and that product handling effort is minimized with maximized earnings

[225]. Quality is something very hard to define, but it is a measure about how confident the user is of the services from the operator or vendor. It is always about quality and how the product behaves during live operations. However, fault-free products most likely will not be affordable [225].

The project life cycle is the link between product life cycle and methodology used for creating the IT Product and IT Services (i.e. SDLC). The positive relationship between IT Products and IT Services within the boundary of IT Processes; which further fit into the generic mapping framework linking Product Life Cycle, Project Life Cycle and SDLC helps in creating an awareness amongst the management teams and IT specialists about the right product quality expectation. This new phenomenon of thinking about mutually dependent lifecycles in IT business segments is in-line with one of Steven Covey's quotes in The *Seven Habits of Highly Effective People* [275], i.e. "Begin with the end in mind". As such, all IT specialists should view IT project-successes from a broader perspective of product life cycle from the start of the life cycle till the end-of-life of the end-product.

In summary, all IT Products and IT Services within the boundary of IT Processes will traverse product life cycle once; *n*-times of project life cycle and *x*-times of SDLC. The overall performances of IT Products and IT Services are greatly dependent on the quality of IT Processes. A well-perceived and accepted end-product from the end-user perspective should traverse all stages of product life cycle; not limiting to project life cycle only. By doing so, it drives operational excellence, product perfection, and elevates process maturity for now and in years to come. When the overall business processes are in place, the route to quality and operational excellence is the next milestone.

8.2 Integration of Six Sigma Practices Assessment

This section is the synthesis summary to illustrate the paths that the research team had undergone as a result of three successful Six Sigma implementation in the case companies mentioned in Chapter 5, 6 and 7. This synthesis summary reveals how the research team worked through three Six Sigma projects with special challenges in the field of IT Process, IT Product and IT Service in Malaysian IT industry.

The dynamic and ever changing customer needs are pushing IT companies to search for a better, comprehensive, continuous improvement and flexible quality initiative that contributes toward reduction of company costing and better continuous improvement in size and speed of return-on-investment. Any quality initiative that opts for a "fixed" operational plan is deterring IT companies from sustaining competative advantages. It is increasingly important to view an IT company as a 'learning organization'; which is capable of acquiring knowledge and innovating fast enough to survive and thrive in a rapidly changing environment and demanding customer requirement. Hence, the Six Sigma efforts are not only attractive as a way to address nagging problems in term of product failures or gaps in customer service and customer satisfaction. Embarking on a Six Sigma initiatives and efforts begins with a decision to change, to learn and to adopt methods that can boost the performance of the organization [152].

The collective outcomes of extensive theory-based literature reviews of IT and non-IT examples; as well as the research effort and qualitative collection of lessons learned after the successful implementation of Six Sigma practices to the three case studies in the IT industry, it has become clearer that the criteria and decisions on how to tailor the Six Sigma approach based on three primary interrelated elements of **“broad questions and decisions”** factors:

- Firstly, the assessment of potential business improvement opportunities will tackle high level specific problems to determine if a ‘renewal’ or ‘change of business’ is needed for the company by scaling the required/targeted efforts in the Six Sigma initiative(s). Most importantly, the significant financial gains from Six Sigma may exceed in value by the intangible benefits.
- Secondly, the factor checklists for Six Sigma practice(s) consideration. The outcome of successful implementation of Six Sigma practice(s) in the three case study company give rise to a compiled list of basic questions relating to the preparation of start-up effort in Six Sigma practices for IT projects are discussed. No doubt there may be more key questions for consideration, items in the checklists are the main discussed questions that arised during discussion with respective case company’s management team at the preliminary analysis phase before the start of a Six Sigma initiative.
- Thirdly, the mapping flow chart of integrating of exisitng quality improvement methodology(ies) with Six Sigma practice(s) and project(s). This framework is capable of examining the interplay of quality performance of the existing case company’s (i.e. either formally or informally), as well as the firm resources, quality approach capabilities and quality competencies. The flow chart provide a broad overview of how to integrate Six Sigma efforts into existing QIM to establish an extension of continuous QIM direction for any IT projects in Malaysia’s IT industry. This mapping offers different options of Six Sigma strategies in “Process Improvement”, “Design and Redesign” and “Process Management”.

8.2.1 High Level Potential Business Improvement Opportunities Assessment

Prior to implementing Six Sigma efforts to the case study companies, a number of essential questions and facts, there are a number of consideration required (Figure 99) in order to gear towards Six Sigma change(s) pertaining to potential business improvement opportunities assessment are:

A) **Current Quality/Service Peformance Evaluation** – Six Sigma makes the evaluation of current performance more concrete by assessing “Where your company is today?”, “Is your company underperforming?”, “How effective and efficient is your company?”, “What is the level of rework?”, “How satisfied is our customer?” etc. These assessments allow the case companies to draw conclusions about current performance to decide if critical improvement and changes are needed to enahance the company's ability to deliver value to customers.

B) **Need for Financial and Competitive opportunity** – Unless the company is already in place with a strong, effective and efficient process; it may not be realistic to take on every business activity simultaneously for Six Sigma implementation. Hence, it is an important choice to decide Six Sigma projects which has significant impact in the early success as well as financial benefits and competitive opportunity.

- Six Sigma initiatives is a "variation" perspective approach where significant "measures" in getting Sigma scores on processess throughout the Project Life Cycle takes time and resource. The aim is to drive for **long term improvements** where **short term focus of result/outcome** of Six Sigma DMAIC or DFSS approach are reflected (e.g. within 4-6 months) after the implementation. Generally, the team should factor in 6-9 months for the first wave of DMAIC or DFSS project to be completed and results to be concrete.
- The objective of Six Sigma practice(s) is driving to reduce or narrow variation and/or gap to such a level that can be squeezed within the limits defined by customer's specification. The next question would be how much improvement is possible and does it justify the need for financial and competitive opportunity? An informal interview with a Six Sigma team member of Nielsen (Malaysia) revealed that it is important to justify an agreeable "**target level of improvement from existing variation**" prior to deciding any Six Sigma efforts (Nielson Malaysia is targetting at 20% of improvement for each initiative of Six Sigma implementation).

  The outsomes as a result of Six Sigma adoptions are only anecdotes and claimed successes. Therefore, the six sigma team and upper management requires to work hand-in-hand in deciding the "target level of improvement". This is to ensure effort and time spent on Six Sigma initiatives is consistent with the management's expectation and the bottom line should be results-focused. The Six Sigma team should not be overly optimistic in resolving all variations at one-go, such as targeting at a 6σ level of quality as opposed to current 1.5σ. It is important to keep the Six Sigma practice(s) scope small, focused, meaningful and manageable. A diligent effort, careful and strategic plan is the key to maximize the benefits of the effort in delivering the "targeted level of improvement from existing variation".

Source: Research analysis compilation

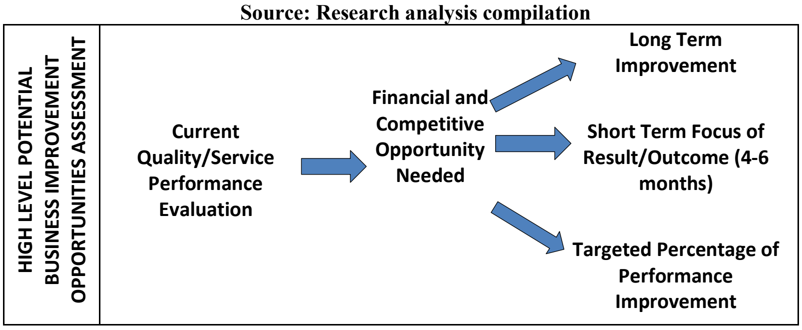


Figure 99 High Level Potential Business Improvement Opportunities Assessment

8.2.2 Key Questions to Six Sigma Practices and Project Assessment

Next, without the input and support of key players from the case company's management team, there is no way the research team can gain management support to implement long-term Six Sigma initiatives to realize business benefits, feasibility advantages and organization impact. The preceding list of key questions criteria to Six Sigma practice(s) and project(s) assessment (Figure 100) are:

Source: Research analysis compilation

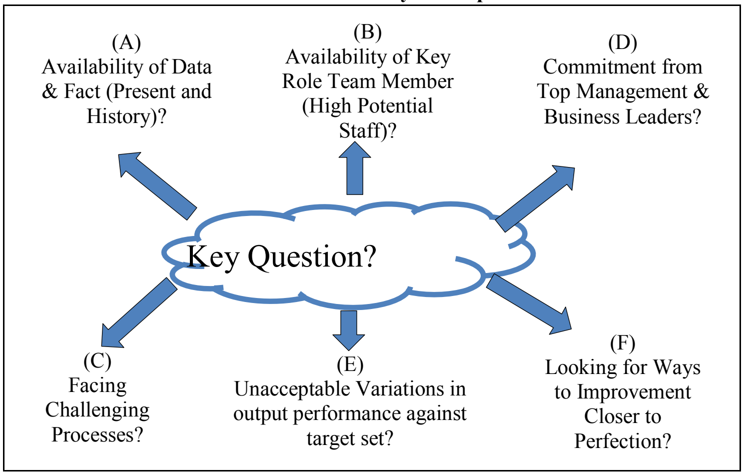


Figure 100 Key Questions to Six Sigma Practices and Projects Assessment

A) Availability of Data & Fact (Present and History)?

Six Sigma is a powerful data-driven approach and the key concept of "management by fact" always address the detailed statistical-based analysis as a means of continous measurement which other QA approaches lack. In view of the dynamic nature of customer needs, it is important to define what are the 'key measures" to gauging business performance which has direct impact on customer satisfaction. By saying so, one of the biggest challenges and sometimes obstacles to Six Sigma implementation is the ability to define and measure intangibles (in IT services) and more subjective metrics. Even though getting a larger volume of data may be difficult if not impossible, this shouldn't deter anyone from managing and measuring business based on data and facts.

B) Availability of Key Role Team Member (High-Potential Staff)?

In most non-IT companies, Black Belts are viewed by the top leaders as high-potential future leaders of the organization for Six Sigma implementation. Although Black-Belts are the engine that propel Six Sigma initiatives [276], choosing the right people to be Black Belts is essential to success.

Due to the nature of the IT industry, the high-potential Six Sigma key role need not be the organization leaders but should be someone that encompasses both hard (analytical and statistical) and soft (leadership and people) skills. Typically, the high-potential candidates should possess: (1) A clear understanding of company's business strategies and objectives; (2) A strong process orientation; (3) A solid knowledge and ability to apply statistical/analytical tools and techniques; (4) Strong facilitation, teaching, and team-building skills; (5) Change management skills and experience; and (6) Cross-functional business and work experience.

In Six Sigma practices and project implementation, project managers and project leaders are among the potential high-potential staff to be selected; and a considerable time will be taken to equip them with specific training needed to successfully execute their roles. It is important to select the high-potential staff within the same IT industry and not an outsider; as managing an IT project is considerably different from any non-IT industry which requires different skill-sets and expertise from IT project management knowledge areas.

C) <u>Facing Challenging Processes?</u>

Whenever a concern arises, i.e. bottlenecks slowing down the entire work flow, the focus is always on the end result outputs. What's more, bottlenecks tend to happen with the most important process. In most cases, the project team will link problem matters to learnings gained from the lessons learned session. In the IT industry, formally conducted lessons learned session are traditionally held during project close-out (towards and near project completion) where sharing of "what the team has done right" as well as "what mistakes the team has performed" are carried out amongst the project team members. This is the time where the team members making use of project knowledge and experience to promote the recurrence of desireable outcome (i.e. good project practices) and preclude the recurrence of those undesirable outcomes (i.e. unhealthy project practices).

It is common that despite several rounds of lessons learned sessions, the same "repeated" issues and problems are still calling out for attention. Formal and consistent follow-up sessions after lessons learned meetings are seen as "learning on paper" where normally team members are being informed about the mistakes that she/he performed and the consequences/implications the project faced as a result of non-conformances.

Although appropriate actions were taken, little attention is given to tackle the problem in proactive manner to extend the learning process to develop root-cause-focused solutions. This makes the entire project processes challenging where 'focused solutions" may seem difficult and chances of recurrence of known-undesirables continues. Hence, it is important to raise the awareness of focused-assessment on challenging processes' strengths and weaknesses, not to meet current compliance only but to focus on immediate competitive needs and continuous improvements of the organization.

D) <u>Commitment from Top Management & Business Leaders?</u>

One of the difficulties undermining most quality improvement initiatives in the IT industry is the weak commitment and lack of involvement of the organization's top management and business leaders. This is clearly demonstrated in the major revision of ISO in the year 2000 (ISO9001:2000) with radical change to demand the involvement of upper executives and management to integrate quality into business system.

One of the key innovations Six Sigma brings is the ability of cross-functional as well as top-down hierarchical management. Top management and business leaders are responsible for setting up a vision for Six Sigma implementation. They also empower the other role holders with the freedom and resources to explore new ideas for breakthrough improvements. A Six Sigma vision of business leadership creates a closed-looped system where support and encouragement from top-down increases the chances of Six Sigma implementation as companywide directives, forces. Decisions and initiatives are consistent throughout project life cycle. Six Sigma provides overall companywide directives where it is made up of essential components that needed to combined (top-down and cross-functional) to drive improved business performance.

E) <u>Unacceptable Variations in output performance today against target set?</u>

IT industry is a project-based environment where job assignments and resource assignments are mainly skewed towards project-based work. Each project has its own requirements and varies from project-to-project. In view of the dynamic nature and ever changing customer needs, it is always a challenging task to strategize a 'fixed" operational plan from operations to customer service to maximize the impact of limited scarce resources for better product quality and greater customer satisfaction.

The so call "fixed" and "one size fits all" universal project plan results in unacceptable variation(s) against target and benchmark set previously. Due to the context of rapidly evolving and expanding IT markets and IT industry growth, a continuous process improvement model with flexible-system capabilities framework is indeed more suitable for the IT industry to gauge business performance to cope with the demanding performance for quality services and better customer satisfaction.

F) <u>Ways for Improvement and to be closer to perfection?</u>

Despite detailed and proper planning, adoption of new ideas and approaches involves risk. Though the companywide manufacturing firm like General Electric or Motorola aims for 6σ for most of its processes, it doesn't mean that every company starting with Six Sigma efforts must achieve 6σ in order to benefit from Six Sigma practices. The bottom line is Six Sigma helps to gain insights to strike a balance between push-and-pull in accomodating people and demanding performance resulting in broad business success.

Even though most companies are operating between 3σ and 4σ only [277], the proven benefits as a result of Six Sigma implementation inclusive of cost reduction, productivity improvement, market–share growth, customer retention, cycle-time reduction, culture change, product and service development etc. Hence, one should view Six Sigma as another potential option in the IT industry to achieve breakthrough closer to perfection in tacking specific problems to renew and broaden Six Sigma beyond manufacturing in the entire and crossed departmental activities.

Lately, practitioners are integrating two or more QIMs into a more powerful and effective hybrid QIM, addressing many of the weaknesses and retaining most of the strengths of each strategy [13, 98, 162, 278]. The proposed combined framework integrates tools and techniques within the methodology to enhance the bottom-line results and win customer loyalty. Implementation of such proposed framework shows dramatic improvement in the key metrics (such as defect per unit, process capability index, mean and standard deviation of casting density, yield, and overall equipment effectiveness) and a substantial financial savings can be generated by the organization [35]. Furthermore, this new approach of integrating two or more QIMs creates awareness to organizations to adopt “another” potential QIM which may suit an organization better and provide the best fit for a company.

This approach of combined methodology not only provides a framework for implementation but also enables business leaders to quantify the risk of failures by focusing purely on a single methodology in an evolving and unpredictable time frame towards reaching maturity. Moreover, the time frames to transform a conventional organization to an integrated QIM vary tremendously across industries, and even across firms in the same industry. A comprehensive literature review by the author has highlighted the degree of alignment and integration of Six Sigma in various combinations of QIM in a journal publication [13]. The discussed combinations of QIM integration are: (1) Six Sigma–CMM [16, 99]; (2) Lean–Sigma [83, 97, 144]; (3) ITIL–Six Sigma [18, 34, 65, 76] and (4) PSP–Six Sigma [58, 59].

The new development of integration framework of QIM with Six Sigma practices (Figure 101) provides necessary guidelines to IT company on the overall “big picture” of how to make the start-up decision. It aims to develop the high-level “mapping” and demonstrating how IT company with and without formal/informal QIM can be integrated and implemented with Six Sigma practices to close the gap of variation between QA and QC. The following elements are interrelated and the framework provide guidelines on how to make start-up decision prior expanding current QIM to incorporate Six Sigma practices as part of the operational mechanism.

8.2.3 Decision Criteria for Integration of QIM With Six Sigma Practices and Projects

Source: Research analysis compilation

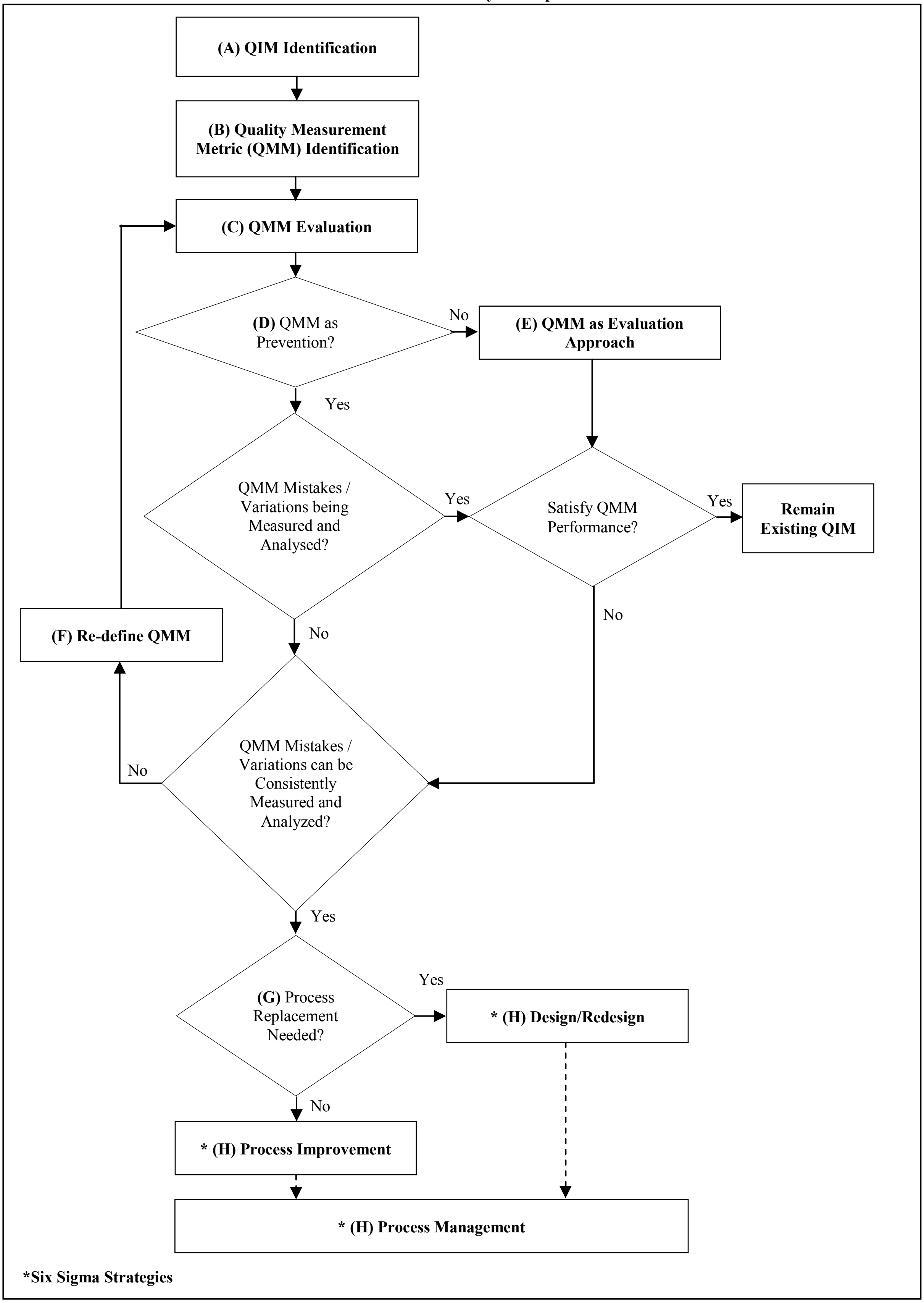


Figure 101 Integration of QIM With Six Sigma Practices and Projects

The flow chart of the "decision criteria for integration of QIM with Six Sigma practices and projects" aims to assist any SMEs in Malaysia IT industry to define quality measurement metric(s) for Six Sigma implementation and integration process. The decision criteria flow chart discussed in this section are interrelated and provide guidelines to any companies on how to make start-up decision prior to expanding current QIM to incorporate Six Sigma practices as part of the operational mechanism. This flow chart was derived as a result of collective outcomes of extensive theory-based literature reviews as well as collective research efforts and qualitative collection of lessons learned from successful implementation of Six Sigma practices to the three case companies (i.e. SYNDES, IS Support UNMC and Company-C). Following are the list of decision criteria for consideration:

A) <u>QIM Identifcation</u>

This step-by-step flow chart will kick start the Six Sigma effort with the first step of identifying existing QIM (if any) for assessment (Figure 102). By identifying the currently adopted QIM, the research team is capable to find out the relevant quality directive(s) for the company. The traditional management approach of QIM selection and adoption process is mostly skewed towards the objectives of quality planning and quality assurance (QA) where the efforts on quality control (QC) and quality improvement (QI) are often being overlooked and neglected.

In IT field, QA attempts to improve and stabilize production (normally associated with processes) to avoid, or at least minimize, issues which led to the defect(s) and variation(s) in the first place; whereas QC emphasizes testing of products/services to uncover and reduce defects/variations and reporting to the project team who make the decision to allow or deny product/service release [13]. Hence, it is important for the research team to identify the QIM of the case company be it in QA or QA&QC prior to implementing or integrating with Six Sigma practices. The aim is to scale the initiative effort accordingly to better understand the case company's procedures to allow greater ability to carry out both the minor adjustments and the major shifts for strategic change.

Source: Research analysis compilation

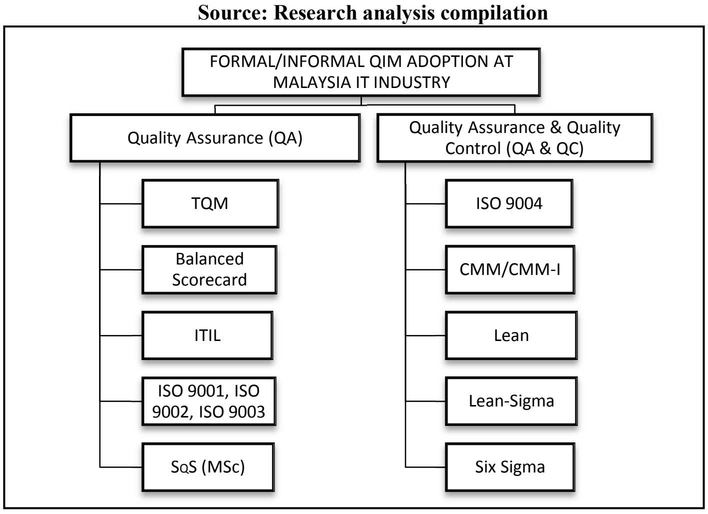


Figure 102 Formal and Informal QIM Adoption in the Malaysia's IT Industry

B) Quality Measurement Metric (QMM) Identification

QMM is the foundation of software quality requirements controlling, it is critical to quality improvement in software development and it is used as a benchmark to gauge the quality performance of software products/services [105]. In preparing the case company for Six Sigma practices, there is an urgent need to identify the set of metrics for quality measurements for respective identified QIM. The ability to identify QMM helps the management to fully understand the "real" performance of the case company; as well as to explore possible paths to better services, better customer satisfaction, better quality output, lower cost and realisation of new capabilities etc.

C) QMM Evaluation

Majority of the traditional QIM placed great emphasis on predefined-set of preventive and proactive rules such as "what to do" or "how to do" or "what and how to do" and "lesson learned". The over-emphasis of these predefined-rules and aspects of evaluation criteria (QMM) of the traditional quality improvements indeed built a strong foundation basis in quality management start-up; but in long-term struggle to promise on-going revolutionary improvement. Therefore, many practitioners are exploring tools and techniques as a medium to operations' evaluation hoping to provide a well-rounded QIM which focuses not only on current business problems, but also capable of moving forward in the future with continuous improvements. The sustainability and relevance of the adopted QIM should be viewed in long term allowing the company to strategize its businesses with the capability of evaluating and measuring the effectiveness and efficiency of current business operations activities [13] in view of demanding customer expectations over time.

In view of the research outcome from the three case companies and the author's literature review [13], the QIM is either skewed towards the "prevention" approach of quality planning and quality assurance (QA); or skewed towards the "evaluation" approach of quality control (QC) and quality improvement (QI). There are always too many critical "defects" and "opportunities" to improve but it may not be realistic to take on every business activity simultaneously. Setting effective improvement priorities is necessary to tackle the problems and to develop root-cause solutions. The clue is to focus on the immediate needs of the business that is most important but least efficient/effective.

D) QMM as Prevention Approach (QA)

Quality Assurance involved planned systematic management processes and activities that aim to achieve targeted business goals within a period of time. It focuses on planning, coordinating and documenting processes to ensure quality in the delivery of good and services. It is a systematic measurement that benchmark actual performance with a standard. It monitors the processes and an associated operational loop (two-ways) that confers error prevention [279].

For example in the event of a software release, the quality assurance stage begins with a set of regulations, procedures and selection of software release checklists that govern the smooth software release process. It then monitors thoroughly each step/checklist involved in the release process to ensure schedules, user requirement and standards are met accordingly. One of the major aspects of quality assurance involves the prevention of quality problems. This can be established by a systematic assessment of its adequacy and conformance audit of the operation system. These aspects combined together provide confidence that a product or service fulfils the quality requirements.

E) <u>QMM as Evaluation Approach (QC, QA&QC)</u>

QA is indeed in contrast when compared to QC in terms of functions and processes where QC is focused on process outputs. QC is an observation technique and activity used to fulfill requirements for quality [279]. It focuses on the initiation of the evaluation process to ensure a level of excellence is achieved in a service or product. The common step involved in QC includes the analysis of a service, product, or process for specific minimum levels of excellence. From the evaluation and measurement process, errors are identified and rectified immediately. This system implements activities and techniques to maintain quality in a service and product. It finds and eliminates causes of quality problems to satisfy customer requirements.

This is the reason why there is a need to create awareness and to explore the potential alignment and integration of existing QIM with other QIM(s). It is to have a focused-extension in both QA and QC, and to handle demanding customers. Although this move requires much effort, time, resources and culture changes; the potential benefits derived is long-term and there are attractive long run market opportunities.

F) <u>Decision Criteria Chart: Criteria for Six Sigma Integration</u>

In view of many QA approaches that are still being based on opinion and assumption as a result of growing emphasis in certifications and audits, it hampered many company’s improvement efforts. Certifications and audits (i.e. internal and external) activities have somehow drawn resources away from process improvement efforts.

Measurement is probably the biggest “investment” any organization makes in its Six Sigma initiatives. The availability of historical data for Six Sigma practices may seem to be a challenge, what’s more getting enough data to use to comparatively measure core business processes can take weeks or even months of effort. Six Sigma effort allows an organization to scale your efforts, from tackling specific problems to renewing the entire business. Therefore, any company's QMM falls into prevention approach and is ready for Six Sigma integration (i.e. from QA to QA&QC), one must ensure the identified QMM "is current" and "can be consistently" measured and analyzed throughout the Six Sigma adoption. Therefore, it is most important and critical to Six Sigma practices that the team asks critical questions about criteria in preparing themselves for Six Sigma initiatives.

G) Decision Criteria Chart: Integration of Six Sgima Strategies into current QIM

Due to the mis-interpretations between QA and QC, there is increasing pressure faced by QM teams to seek for a better QIM which provides a comprehensive top-down approach (QA and QC) that allows the organization to strive for competency and competitiveness among its competitors. In short, an organization may change with time and applying such a narrow approach in selecting a certain methodology may prove to be a mistake in the long run. Therefore, there is a need for big organizations or multi-national organizations to take a lead in aligning or integrating different QIMs to cope with increasing customers' needs and demand. Many organizations are working to overcome single QIM obstacles to achieve consistent quality in the IT delivery process.

The ultimate benefit of Six Sigma effort is the long-term development of a "measurement infrastructure" which other QA approaches do not provide. The absence of a "measurement metric" will result in: (1) Drawing false conclusion based on incomplete analysis; (2) Drawing correct conclusions but not backed them up with statistical validation; or (3) Lack of optimization in decision process.

H) Six Sigma Strategies

Six Sigma is made up of essential components that combine to drive improved business performance. The ultimate outcome is to ensure results are measured and that Six Sigma solutions pay off. Regardless of the scale or scope of the integration of Six Sigma practices, the common arguments against which Six Sigma strategies should be adopted is the challenge that arise during implementation.

- **Process Improvement** – It refers to a strategy of developing a focused solution so as to eliminate the root causes of business performance problems. Other terms that have been used synonymously include 'continuous improvement', 'incremental improvement' or 'Kaizen'. It seeks to fix a problem while leaving the basic structure of the work process intact. Thus, the majority of Six Sigma projects are Process Improvement efforts.
- **Design/Redesign** – The objective is not to fix but rather to replace a process (i.e. new process) with a new one. Through careful design, planning, controlling and tracking; the case company will reach a whole new level of performance. It is often called "Six Sigma Design" and involves changing or redesigning the process at the early stage of the product/process/service life cycle [11]. It is important to note that Design/Redesign approach is not a replacement for new product introduction process but it is an approach to make

product/process/service more efficient, reliable and capable to meet customer expectations and requirements. It has significant impact in long-term profitability where it increases customer satisfaction and market share.

- **Process Management** – It is viewed as an 'evolutionary' approach where organizations tend to learn and develop slowly. The growth of Process Management as a practice actually parallels the expansion of Six Sigma into a complete management system within a department or across the organization. In any mature Process Management approach, the themes and methods of Six Sigma become an integral part of running the business.

8.2.4 Integrated Mapping of QIM With Case Company Six Sigma Practices

It is always a key question to IT business leaders of whether or not to start a Six Sigma effort and where to begin Six Sigma effort. This section sumarizes the outcomes of the three case studies as a result of a roadmap of the three primary "broad questions/decision" framework of:

- High Level Potential Business Improvement Opportunities Assessment (Table 110)
- Key Questions to Six Sigma Practices / Project Assessment (Table 111)
- Flow Chart for Implementation/Integration of QIM With Six Sigma Practices/Projects (Table 112 and Table 113)

8.2.4.1 High Level Potential Business Improvement Opportunities Assessment

Table 110 Case Study Mapping of High Level Potential Business Improvement Opportunities Assessment

Roadmap Mapping	SYNDES Technologies	IS SUPPORT UNMC	Company-C
Current Quality/Service Peformance Evaluation	Significantly Unacceptable	Unacceptable	Significantly Unacceptable
Need for Financial and Competitive opportunity	Threat for Cost Overrun, Incompetency, System Reliability	Internal Operational Improvement, Effectiveness and Efficiency	Threat for Contract Renewal/Continuity
Long Term Improvements	By Project; Project Norm and Project Culture establishment help in long term project management	Culture Establishment among technical and support team	Establish Profile in Banking Industry for long-term business opportunities
Short Term Focus of Result/Outcome	By end of project completion	Immediate	1-2 months
Target Level of Improvement from Existing Variation	30-40%	30-40%	20%
Measurable Result (Tangible)	• Resource Utilization improved by 200% [223] • SRS Changes improved by 87.5% [223] • Establish highly motivated team • Management ability to spend 50% more time exploring business opportunity [223] • Deliverable quality improved by 82.17% [216] • Team Productivity increased by 50% [216]	• Queue Waiting Time improved by 41% (improve by 2.5 cycle) [249] • Front Desk Officers availability increased by 42% [249] • HMS Utilization improved by 92% [249] • Achievement of Incident Satisfaction Survey of 94% [249] • Customer Satisfaction of 94% [249] • Front Desk Officer Idle Waiting Time reduced by 72% [249]	• 100% computation of ticket expiry time • Achievement of better FTE utilization (72%) • SLA performance improved by 28% • Operating cost per month improved by 37.5% • SLA violations improved by 28% • Accuracy of SLA expiry computation improved by 20%
Intangible Result	• Adoption of new SDM of W-Model [223] • Establish highly motivated team [223] • Both business and technical knowledge among business lead and technical lead has been reduce [223] • Mapping of project activities into project schedule [223] • Better team motivation and team spirit [216]	• Establishment of positive work culture	• Creation and adoption of resource utilization prediction chart improve project planning • Establishment of ticket closure by engineer

8.2.4.2 Key Questions to Six Sigma Practices and Project Assessment

Table 111 Case Study Mapping of Key Questions to Six Sigma Practices and Project Assessment

Roadmap Mapping	SYNDES Technologies		IS SUPPORT		Company-C	
Availability of Data and Fact (Present and History)?	Present	History	Present	History	Present	History
	Yes	Partially	Yes	No	Yes	Yes
Availability of Key Role Team Member (HiPo Staff)	• Project Manager • Project Leader • Business Lead • Technical Lead		• Helpdesk Manager		• Operation Manager • Lead Engineer • Helpdesk Project Leader	
Commitment from Top Management & Business Leaders?	• Project Director • Project Manager		• IS Support Manager • Helpdesk Manager		• Executive Director • Operation Director	
Facing Challenging Process?	• Resource Utilization • SRS handling		• Incident logging of attended front desk IT Requests/Services		• Engineer-Ticket Assignment • SLA Performance	
Unacceptable Variations?	• 100 out of 129 bugs are high impact bug • Less than 33.33% of Resource Utilization • 6 out of 10 projects are delayed 40% of changes to SRS throughout project life cycle		98% of attended front desk IT Requests/Services are not logged into HMS		• 326 tickets (59%) out of 554 tickets violated the resolution SLA • Account-2 was reported big slack (50%) in SLA performance • Ineffective and inefficient of Engineer-Ticket Assignment • SLA Performance • More than 50% of tickets were communicated / coordinated towards the end of the resolution time frame	
Looking for Ways to Improvement Closer to Perfection?	Targeting for 2-4 sigma		Targeting for 2-4 sigma		Targeting for 2-4 sigma	

Source: Research analysis compilation

8.2.4.3 Flow Chart Mapping for QIM Integration with Six Sigma Practices and Projects

Table 112 Case Study Mapping of Flow Chart for Integration of QIM With Six Sigma Practices and Projects

Roadmap Mapping	SYNDES Technologies		IS SUPPORT		Company-C	
Identify QIM	Informal ITIL and SQS-1 (MSc)		Informal ITIL		Informal ITIL	
Identify QMM	• On-time delivery Software Quality Performance		Helpdesk Efficiency and Effectiveness		Service Level Performance	
Evaluate QMM	Significant Below Target		Below Target		Significant Below Target	
QMI as Prevention?	Yes		Yes		Yes	
QMI being Measured?	Partially		No		Partially	
QMI can be consistently measured?	Yes		Yes		Yes	
Present/History and Data/Fact Availability?	Present	History	Present	History	Present	History
	Yes	Partially	Yes	No	Yes	Yes
Process Replacement?	Yes		No		No	
Six Sigma DMAIC Practices	**Design/Redesign**		**Process Improvement**		**Process Improvement**	

Source: Research analysis compilation

Table 113 Case Study Mapping of Six Sigma Strategies

<table>
<tr><th></th><th>PROCESS IMPROVE-MENT</th><th>IS SUPPORT</th><th>Company-C</th><th></th><th>SYNDES Technologies</th><th>PROCESS DESIGN / REDESIGN</th><th></th></tr>
<tr><td rowspan="3">DEFINE</td><td>Identify the Problem</td><td>There exists a “gap’ between attended front desk activities against logged incidents in HMS</td><td>There exists a “performance gap” of contractual SLA achievement against actual SLA performance</td><td></td><td>Project delayed, project cost overrun and significant bugs reported after project delivery</td><td>Identify Specific or Broad Problems</td><td rowspan="3">DEFINE</td></tr>
<tr><td>Define Requirement</td><td>Front desk officers to log all attended front desk IT requests/services into HMS</td><td>Engineers and support staff to achieve contractual SLA performance</td><td></td><td>To delivery project within schedule, budget and meeting user requirements</td><td>Define Goal and Change Vision</td></tr>
<tr><td>Set Goals</td><td>To capture all attended front desk IT requests/services into HMS</td><td>To study and analyze ways to improve SLA performance achievement to meet contractual SLA</td><td></td><td>• To analyze and investigate IT operational processes to minimize redundancy, rework, budget overrun, resource under-utilization and schedule slippage.
• Customer to receive customized software within schedule for planned implementation, software are meeting end-users functional and operational needs</td><td>Clarify Scope & Customer Requirements</td></tr>
<tr><td rowspan="3">MEASURE</td><td>Validate Problem and Process</td><td>Significantly high tendency of front desk officers not recording attended IT requests/services into HMS</td><td>• Inefficient and ineffective of engineer assignment to ticket allocation
• Tendency of delayed in ticket closured result in SLA violation</td><td></td><td>• Significant “gaps” between planned and actual performance in software development activities (i.e. software quality)
• Inefficient and ineffective in handling scarce resources</td><td>Measure Performance to Requirements</td><td rowspan="3">MEASURE</td></tr>
<tr><td>Refine Problem and Goal</td><td>HMS does not reflect the real volume of helpdesk activity</td><td>SLA performance achievement is far behind the contractual SLA</td><td rowspan="2"></td><td rowspan="2"><u>OUTPUT MEASURES</u>
• Changes made to SRS
• Project Delivery status
• Number of reported bugs by severity level after project implementation
• Proportion defective by different severity level of reported software bugs
• Number of FTEs involved in PLC
• Compute Sigma for each activities

<u>INPUT/PROCESS MEASURES</u>
• Discrepancy between planned and actual project delivery
• Existence of Unit Test Plan
• Frequency/Effort of QA Testing
• Resource Utilization of project team</td><td rowspan="2">Gather Process Efficiency data</td></tr>
<tr><td>Measure key steps/inputs</td><td><u>OUTPUT MEASURES</u>
• Number of attended front desk IT requests/services not recorded into HMS
• Proportion defective by different front desk IT requests/services types
• Compute Sigma for each activities

<u>INPUT/PROCESS MEASURES</u>
• Discrepancy between attended front desk IT requests/services against logged attended front desk IT request/services
• Cycle time for queue waiting time
• Front desk officer availability
• Utilization of HMS</td><td><u>OUTPUT MEASURES</u>
• Percentage of Respond and Resolution SLA violation
• Proportion defective by different accounts
• Compute Sigma for each activities

<u>INPUT/PROCESS MEASURES</u>
• Discrepancy between contractual Respond and Resolution SLA against actual SLA achievement
• Average Coordination / Communication Time performance for each tickets
• Average Engineer On-site Time
• Engineers Utilization</td></tr>
</table>

ANALYZE	**Develop Casual Hypotheses**	• Most attended front desk IT requests/services are not captured into HMS • Tendency to capture attended IT request/services which requires follow up effort • Lack of HMS monitoring, controlling and tracking	• Most project accounts violated the contractual SLAs • Tendencies of delayed tickets closure by engineers when the tickets are resolved • Conflict and confusion of ticket handling by an engineer • Redundant and overlapping of effort in follow-up assigned ticket		• To maximize resource utilization with existing scarce resources by focusing on existing case company project characteristics and project nature in SDLC • To have a realistic project plan throughout project life cycle (PLC) by implementing project management guidelines	**Identify "best practices"**	ANALYZE
	Identify "vital few" root causes	• Lack of procedure/policy enforcement • Work culture issue • Take easy way out of "Front Desk Cycle Flow" • Lack of awareness of HMS importance to company directive • Effort lacking in acquire user information prior providing services	• Too long awaiting time (coordination / communication time) to resolve a ticket • Engineers shoulder the responsibility of tickets closure to support executive • A common pool of engineers are shared among all project accounts having different SLAs • Significant rework in follow-up effort by support executive to close a resolved ticket		• Most IT projects delayed are due to existence of SRS changes • Obvious business and technical knowledge gap among phases of PLC • Tendency of project team to omit in preparing insufficient project documentation during PLC • Lack of planning effort during project start-up • Despite project delays, the project team faces significant rework	**Assess Process Design** • **Value and non-value adding** • **Bottlenecks/ disconnects** • **Alternate paths**	
	Validate Hypothesis	Validate hypothesis via: • Process Mapping • Input-Process-Variable • Flowcharts • Cause-and-Effect Diagram (Fishbone) • Pareto Diagram • Failure Modes and Effects Analysis (FMEA) • Scatter Plot / Correlation Diagram	Validate hypothesis via: • Process Mapping • Input-Process-Variable • Flowcharts • Cause-and-Effect Diagram (Fishbone) • Pareto Diagram • Failure Modes and Effects Analysis (FMEA) • Scatter Plot / Correlation Diagram		• To review Software Development Methodology (SDM) to optimize resource utilization To find out root-causes contributing to : • project slippages • cost overruns • rework • SRS changes • planning efforts • Quantity of reported bugs	**Refine Requirements**	
IMPROVE	**Develop Ideas to Remove Root Causes**	• Adopt IS Support Request Form as a medium of acquiring user information prior any IT requests/services • Broaden the awareness of culture change recognizing the importance of logging in ALL attended IT requests/services into HMS	• Improve SLAs performance by adopting dedicated engineers • Improve, manage, control and track SLAs performance by using a prediction chart • Broadening the awareness of culture change by recognizing the importance of engineer performing on-time ticket closure • Improve ticket closure by introducing performance incentive for on-time ticket closure		• Exploring how different SMD can be implemented in case company to deliver end result within schedule, budget and meeting requirements • Potential SDM proposal should not change the PLC of project management context as well as the existing project activities of the case company • Changes to workflow should be kept at minimum unless is justify for effectiveness and efficiency • New process proposal should be restricted to available resources unless justification is provided	**Design New Process** • **Challenge assumptions** • **Apply creativity** • **Workflow principles**	IMPROVE

	Test Solutions	Implement of IS Support Request Form at front desk for at least two cycle of observations	• Each project account should assign with dedicated engineers serving same SLA • Use the prediction chart to test prediction of ticket volume and expected SLA performance achievement for at least 4-6 rounds of data cycle		• Proposing to adopt a new SMD to case company • Resources are assigned with new and/or added role at PLC • Improve software quality by adopting structured and proven scientific approach to IT Project Management • Improve current operational workflow to better utilize scarce resources	**Implement New Process, Structures, Systems**	
	Standardize Solution/Measure Results	• Measure the observation outcome and benchmark with HMS • Measure the proportion defective by different front desk IT requests/services • Compute the observed Sigma and compare with Sigma before implementation of IS Support Request Form	• Measure the predicted SLA performance outcome against the prediction chart • Measure the variables contributed to SLA performance • Compute the observed Sigma and compare with Sigma before Six Sigma implementation				
CONTROL	**Establish Standard Measures to Maintain Performance**	• Formalized the adoption of IS Support Request Form • Broaden the awareness of completing "Front Desk Cycle Flow" by logging in ALL attended front desk IT requests/services • Introducing Front Desk Incident Satisfaction Survey for EACH attended front desk activities	• Manage and control the KPI of SLA performance accordingly with the assistance of prediction chart • Review SLA contract to bridge the gap between outsourcing SLA performance level and project costing (ROI)		• Formalized the new SDM to new projects • Broadening crossed-team knowledge sharing among support team and technical team • Introducing performance incentive for milestones accomplishment • Adopting the use of control documents	**Establish Standard Measures to Maintain Performance**	CONTROL
	Correct Problems as Needed	Amend the IS Support Request Form (if needed) to reflect changes of front desk operational process	• Awareness of changes to SLA KPI variables will affect SLA performance and forecast contingency plan is possible with the aid of prediction chart • As the skill level and expertise of engineers improve, the prediction chart should result a better performance (upper scale)		• Review SMD from time to time to accommodate project scale, project nature and project scope • Revise project role(s) within phases of PLC as needed • Do not over-use of control documents, only important control documents are introduce; milestone checkpoint	**Correct Problems as Needed**	

Source: Research analysis compilation

8.3 Project Management Maturity Model (PMMM)

8.3.1 Introduction to PMMM

Today, customers expect service providers and contractors not only to deliver quality product or quality services, but also to manage day-to-day business activities using sound project management practices. In the IT industry, delivering projects within budget, meeting user requirement, delivering within schedule and quality end products is a challenging task for any IT project managers. Furthermore, improvement processes are implemented throughout the project life cycle aiming to push team members toward better efficiciency and effectiveness with lesser rework to meet resource optimization objectives.

In order to stay ahead of competitors and manage projects better, organizations should know if they are doing things the right way. In other word, are both the line management and top management committed to project management; if so, do they have a culture of excellence in handling day-to-day tasks? Improvement in overall efficiency and effectiveness of the company is difficult, hence it is important to know the respective case company's maturity level of project management commitment to be better prepared in dealing and handling potential critical failure factors that hindered effective project management.

Whenever a Six Sigma practices takes place, new processes will be introduced and new ways of doing things will be established. Ultimately, the integration process of Six Sigma aims for better project performance and better customer satisfaction. Therefore, it is important to know the level of project management maturity of the case company such that proactive actions can be planned and taken to ensure continuous improvement in the near future. As such, project management maturity level is the key ingredient to project performance [280] especially in this research project of integrating Six Sigma practices into existing QIM.

8.3.2 Evaluation of Project Management Maturity Model

Maturity in project management is the development of systems and processes that are repetitive in nature and provide a high probability that each project will be a success [218]. Repetitive processes and systems do not guarantee success, they simply increase the probability of success [280]. PMMM is capable of assisting IT organizations to improve project management processes and practices in a structured manner so as to harvest the benefits of well-managed and timely projects [280]. Thus, this is often where the value of a maturity assessment comes into play. As such, it may not be so important to know you are a level-2; but rather what specific actions you will be implementing to move the organization forward and what are the critical failure factors that create obstacles to effective/efficient project management.

Although PMMM is a new concept, the number of PMM models are increasing, both directly and indirectly to assess and strategically plan the project management development and required resources in an organization [281]. There are many maturity models and each maturity model is different in terms of their characteristics, factors and ways that affect level of maturity. CMM/CMM-I, PRINCE, OPM3 and Kerzner PMMM (KPM^3) are some of the examples of maturity models framework allowing assessment of an organization's project management strengths and weaknesses; as well as enabling measurement of the correlation between an organization's project management level and actual project performance [281].

A comprehensive literature review of PMMM and their comparison between CMM/CMM-I, PRINCE, OPM3 and KPM^3 was summarized in Table 114. Most maturity models have some characteristics but not all are strategic assets and hence cannot present competitive advantage. Though maturity models are a component of project management, they are not a holistic representation of the discipline. Maturity models have some limitations from a theoretical perspective, they are based on software maturity models that lack a theoretical basis [281].

Table 114 Comparison of PMMM

Criteria	CMM/CMM-I [140, 278, 281, 282]	Kerzner PMMM [218, 281]	PRINCE2 [281, 283]	OPM3 [281, 284]
Acronym	Capability Maturity Model Integration, CMM	Kerzner PM3	PRINCE, P2MM	Organizational Project Management Maturity Model
Maturity Level [281]	1-5	1-5	1-5	-
Maturity Level Description	L1 – Initial / Performed L2 – Managed / Repeatable L3 – Defined L4 – Quantitatively Managed L5 – Optimizing	L1 – Common Language L2 – Common Process L3 – Singular Methodology L4 – Benchmarking L5 – Continuous Improvement	L1 – Ad-hoc L2 – Planned L3 – Managed at Project Level L4 – Managed at Corporate Level L5 – Continuous Learning	-
Advantages	• Effectively support and address knowledge management and learning [140] • It is a general and powerful tool for understanding and improving general business process performance [285]	• Design to meet the needs of a broad array of industries and cultures [218] • Making changes to the model is perfectly acceptable [218] • Decreased cycle time and greater customer satisfaction [218] • Better risk management lead to better decision making [218]	• Structured approach to project management • provides a common language for all participants in the project • methodology is scalable and can be tailored to suit the specific requirements and constraints of the project and the environment [286]	• Strengthens the link between strategic planning and execution, so project outcomes are predictable, reliable, consistent, and correlate with organizational success. • Identifies the best practices which support the implementation of organizational strategy through successful projects. • Identifies the specific capabilities which make up the Best Practices, and the dependencies among those Capabilities and Best Practices
Critique	• process maturity according to the CMM was not necessarily mandatory for successful software development. • CMM too complicated for general application [287] • Confusing use of PM terminology. CMM-I treat "identification", "base-lining", "status accounting" and "interface control" as part of configuration management [287]. • The application approach is too prescriptive, any departure from the use of the preset standard result in a lower maturity score [287]	• low assessment difficulty [281] • non-existence of portfolio management process [281]	• sometimes considered inappropriate for small projects or where requirements are expected to change due to the work required in creating and maintaining documents, logs and lists •	• It does not collect the information necessary for an organization to implement, that it produces erroneous results, and that in the long run these facts will destroy *OPM3*. • *OPM3* Online does not reflect the *OPM3* Standard because it does not articulate assessment questions in terms of the testable *OPM3* capability statements that comprise the majority of the *OPM3* Standard [288]

Source: Research analysis compilation

Despite the critiques of KPM^3 being low assessment difficulty and non-existence of portfolio management process; it was selected as a medium for project management maturity level assessment as it was designed to meet the needs of a broad array of industries and cultures especially for the three different nature of the case companies in this thesis. Furthermore, making changes to the model is perfectly acceptable and KPM^3 introduces a process management maturity assessment which was developed to assess the implementation of Business Process

Management and the achievements. Most importantly, KPM^3 assessment is designed for organization to objectively identify strengths and weaknesses in relation to their project management practices. The result of the five levels of assessment helps to determine where improvements were the most value so that organization can establish a specific implementation goal. This model is chosen because of its simplicity and availability; and it is a result of real-life application and it has been industry validated within a number of world class organizations [289].

Furthermore, it is always a debatable topic about levels of maturity; where there exists a common misbelief that all work must be accomplished sequentially (i.e. in series) before moving to the next level of maturity. This has not always been considered as a valid statement. The research team believes that certain levels can and do overlap. The KPM^3 revealed that the magnitude of the overlap is greatly based on the amount of risk the organization is willing to tolerate. In any circumstances overlapping occurs, the order in which the phases are completed cannot change [218].

Firstly, KPM^3 assess the way the three case studies are performing and the state of respective process at five different levels factoring in variables such as visibility, consistency and control. The computed scores will show how far along the maturity curve respective case companies have progressed; and this helps to strategize and prioritize organization's next steps to increase competitive position in the wider marketplace. In effect, KPM^3 is a good model for the measurement of project management maturity, which creates a strategic plan for moving project management forward in an organization; as well as agreeing how a company can achieve superior levels of project management maturity.

8.3.3 The Kerzner's PMMM

According to Kerzner [218], the Kerzner's Project Management Maturity Model (Figure 103) comprised of five levels and each level represents a different degree of maturity in project management:

- **Level-1 Common Language**: It recognizes the importance of project management and the need for good understanding of basic knowledge on project management, along with the accompanying language and terminology.
- **Level-2 Common Process**: It recognizes common processes need to be defined and developed such that successes on one project can be repeated and failure can be avoided on other projects. This level also recognizes that project management principles can be applied to and support other methodologies employed by the company.
- **Level-3 Singular Methodology**: It recognizes the synergistic effect of combining all corporate methodologies into a singular methodology for better control. It has the highest risk and highest degree of difficulty. Once committed, the time and effort needed to achieve higher level of maturity have a low degree of difficulty. May require a major shift in the corporate culture.

- **Level-4 Benchmarking**: It recognizes that process improvement is necessary and must be on a continuous basis. The company must decide “whom” and “what” to benchmark.
- **Level-5 Continuous Improvement**: The organization evaluates the information obtained through benchmarking and decides whether or not this information will enhance the singular methodology.

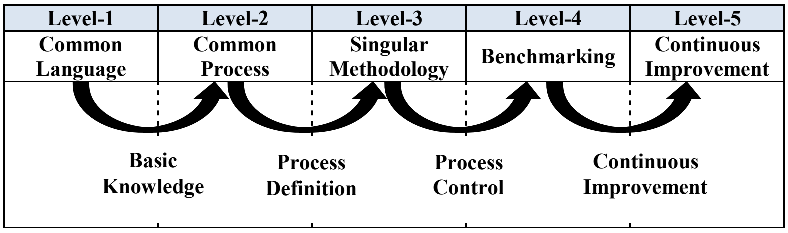


Figure 103 The Five Levels of Kerzner’s Project Management Maturity [218]

8.3.4 The Life Cycle Phases for Project Management Maturity

Project management never stops and it can always be improved. The current study strives for continuous improvement in project management and the learning process for maturity is commonly measured in years. Project management maturity is the development of systems and processes that are repetitive in nature and provide a high probability that each project will be successful. Repetitive processes and systems do not guarantee success; simply increase the probability of success. As such, a company can be mature in project management but not be excellent in project management.

Table 115 summarized the life cycle phases for project management maturity of KPM[3]. According to Kerzner [218] , virtually every company that achieves some level of maturity goes through these phases. The culture of the organization and the nature of the business will dictate the amount of time spend in each of the phases.

Table 115 The Five Phases of the Kerzner’s Project Management Life Cycle [218]

Embryonic	Executive Management Acceptance	Line Management Acceptance	Growth	Maturity
Recognize need	Get visible executive support	Get in management support	Recognize use of life cycle phases	Develop a management cost/schedule control system
Recognize benefits	Achieve executive understanding of project management	Achieve line management commitment	Develop a project management methodology	Integrate cost and schedule control
Recognize applications	Establish project sponsorship at executive levels	Provide line management education	Make the commitment to planning	Develop educational program to enhance project management skill
Recognize what must be done	Become willing to change way of doing business	Become willing to release employees for project management training	Minimize creeping scope and select a tracking system	N/A

In the **embryonic** phase, both middle management and senior management must recognized the need for; benefits of; and application of project management. Once executives and managers realize that project management not only affects the corporate bottom line but also is a necessity for survival, the maturity process is accelerated. The second phase of the project management life cycle (**Executive Management Acceptance** phase), it is critical that executives "visibly" identify their support if the organization is to become mature in project management [218].

Lack of visible executive support is the biggest detriment to achieving maturity and excellence in project management. The third phase in the maturity model is **line management support**. Line managers do not necessarily need a strong understanding of the project management tools, but they must understand the principles of project management since it is the line managers who are responsible for the staffing of the project [218]. Besides, it is a necessity for line managers to provide visible support and commitment for the process. In the "**Growth**" phase, the embryonic phase, executive management, acceptance phase and line management support phase MUST be completed before this phase can be completed. Senior management's knowledge of project management and support can accelerate this phase [218]. The last phase which is the "**Maturity**" mandates the importance of integrating time and cost through earned value measurement. One is unable to determine the project status by just looking at either the schedule or the cost. Development of a long-term educational program can maintain a particular maturity position (e.g. Lessons Learned files) [218]. Without "documented" lessons learned, a company can quickly revert from maturity to immaturity in project management. Knowledge is lost and past mistakes are repeated.

8.4 Critical Success Factors and Critical Resistance Factors in the Project Management Life Cycle

Besides looking into the assessment of PMM level and how project performance can be enhanced by the higher level of project management maturity, it is important to pay attention to both the "critical success factors" as well as the "critical failure factors" contributing to success and obstacles to effective project management [218]. Most QIMs outline systematic and structured guidance in achievement of quality and operational excellence; underestimating the "potential" of other external factors which may directly and indirectly affect the success rate of QIM implementation and the continuity of QIM implementation as a mean of continuous improvement. Hence, expanding the research synthesis analysis into this area is to further explore the relationship of PMM level affecting the implementation and integration of Six Sigma practices into IT project. Table 116 lists both the critical success factors and critical failure factors for achieving a fully developed project management system.

Table 116 Critical Factors in Project Management Life Cycle [218]

Project Management Life Cycle	Critical Success Factors	Critical Failure Factors
Executive Management Acceptance	• Consider employee recommendations • Recognize that change is necessary • Understand the executive role in project management	• Refuse to consider ideas of associates • Unwilling to admit that change may be necessary • Believe that project management control belongs at executive levels
Line Management	• Willing to place company interest before personal interest	• Reluctant to share information • Refuse to accept accountability

Project Management Life Cycle	Critical Success Factors	Critical Failure Factors
Acceptance	• Willing to accept accountability • Willing to see associates advance	• Not willing to see associates advance
Growth	• Recognize the need for a corporate-wide methodology • Support uniform status monitoring and reporting • Recognize the importance of effective planning	• View a standard methodology as a threat rather than as a benefits • Fail to understand the benefits of project management • Provide only lip service to planning
Maturity	• Recognize that cost and schedule are inseparable • Track actual costs • Develop project management training	• Believe that project status can be determined from schedule alone • See no need to track actual costs • Believe that growth and success in project management are the same

8.5 Project Management Excellence

It is important to understand that any organization that practices project management is not guaranteed that excellence will follow automatically [218]. This is the main reason why an experienced company can use project management routinely for years and still not achieve excellence in project management. Therefore, the definition of project management excellence must extend well beyond experience and success. Organizations excellent in project management create an environment in which there exists a continuous stream of successfully managed projects, where success is measured by having achieved performance that is in the best interest of the whole company, as well as having completed a specific project [218]. As a result, the research synthesis analysis was expanded into the assessment of project management excellence to further explore the excellence level of project management for the three case companies so that assessment outcome can be "benchmarked" for years to come to develop effective continuous improvement in the context of IT project management.

The author adopted Kerzner Project Management Excellence questionnaire because of its consideration of project management integration with other six management processes such as "Integrated Processes", "Culture", "Management Support", "Training and Education", "Informal Project Management" and "Behavioral Excellence" are the key to achieving excellence. The integration of project management amongst these six components of excellence (i.e. Hexagon of Excellence Figure 104) by Kerzner is to foster synergy and to improve team motivation among the project teams; as well as demonstrating team acceptance towards supporting of project management. The details of Kerzner's Hexagon of Excellence are summarized in Table 117.

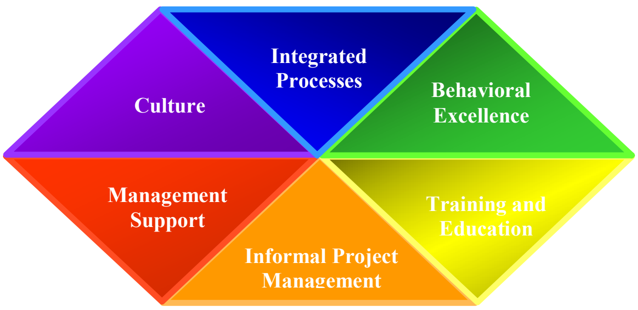


Figure 104 Hexagon of Excellence [218]

Table 117 The Components of Hexagon of Excellence [218]

Components	Description
Integrated Processes	• Companies with separate methodologies for each process may end up with duplication of effort, possibly duplication of resources and even duplication of facilities • As the benefits of synergy and integration become apparent, organization choose to integrate all of these processes
Culture	• Successful implementation of project management creates an organization and culture that changes rapidly due to demands of each project • Change is inevitable. As such, excellent companies realize that competitive success can be achieved only if the organization has achieved a culture that promotes the necessary behavior
Management Support	• Senior managers are the architects of corporate culture. They are charged with making sure that their companies' culture, once accepted, don't come apart • Visible management support is essential to maintaining project management culture • Line Managers should: (1) Shared accountability; (2) Negotiate for deliverables; (3) Project managers help line managers; (4) Empower team members to make decisions
Training and Education	• Establishing project management training programs is one of the greatest challenges because project management involves numerous complex and interrelated skills (qualitative/behavioral, organizational and quantitative) • The focus are on: (1) The need for training; (2) Identify who needs training; (3) Design and conducting the training; (4) Measuring training's return on $$$ investment • Effective training supports project management as a profession
Informal Project Management	Four Critical Elements for informal project management: • Communications – Project communication includes dispensing info. On decision made, work authorization, negotiations and project reports • Cooperation – It is the willingness of individuals to work others for the benefits of all. It includes the voluntary actions of a team working together toward a favorable result • Teamwork – Is the work performed by people acting together with a spirit of cooperation under the limits of coordination. People confuse teamwork with morale. Morale has more to do with attitudes towards work than it has to do with the work itself • Trust – Trusting everyone involved in executing a project is critical. It is the key to successful implementation of informal project management
Behavioral Excellence	Excellent companies realize that project failures have more to do with behavioral shortcomings –poor employee morale, negative human relations, low productivity and lack of commitment.

8.6 Assessment of Project Management Maturity Level and Project Management Excellence

A questionnaire of project management assessment was conducted with the three case companies involving first line management team, management team as well as staff responsible in IT project management. This survey was carried out as post Six Sigma implementation follow-up to assess the level of respective case companies' "project management maturity" and "project management excellence" in the context of IT project management. It was carried out in the second quarter of 2014 and the data collection process lasted for 3-5 months and the result were analyzed, tabulated and summarized using the scoring sheet of respective project management's assessment approach.

The research team has selected Kerzner's PMM questionnaire for the PMMM assessment as well as Kerzner's PM Excellence questionnaire for the project management excellence assessment. A total of 70 questions (i.e. Q10 – Q79 in Appendix-3) concerning how "mature" and how "excellence" one believes their organization is in the context of IT project management are adopted from Kerzner's book [218]. The survey used in this study consisted of three parts:

- Demographic (Q1 – Q9)
- General Project Management Practices (Q10 – Q14)
- Assessment of Project Management Maturity (Q15 – Q34)
- Assessment of Project Management Excellence(Q35 – Q79)

The questionnaire was distributed to selected respondents (i.e. total of seven respondents) in the case companies assessing respective PMM level and PM Excellence; the corresponding respondents profile are summarized in Table 118.

Table 118 Profile of Respondents – Assessment of Project Management Maturity and Excellence Level

Case Company	Case Study-1 SYNDES Technologies		Case Study-2 IS Support UNMC			Case Study-3 Company-C	
Respondent's Designation	Project Director	Project Manager	IT Manager	Front Desk Executive	IT Executive	Executive Director	Operation Manager
Number of years in the Project Management (Years)	5-8	3-5	10-15	1-2	2-3	10-15	8-10
Number of reporting subordinates	15-20	15-20	40-50	1	2-4	100-200	100-150
Number of years in the company	5-8	3-5	8-10	3-5	3-5	5-10	5-10
IT Management Team?	Yes	Yes	Yes	No	No	Yes	Yes

Source: Research analysis compilation

8.6.1 Assessment of Project Management Maturity Level

There are many PMMM assessment tools in the market; from simple to complex; generic or industry specific. Ultimately, they all seek similar objectives to measure an organization's project management strengths and weaknesses, and to identify improvement opportunities. The research team has selected Kerzner's PMM questionnaire for the PMMM assessment.

The twenty questions (Q15-Q34 of Appendix-3) from the questionnaire assessing the PMM level is using the 'bipolar scale' concept where there is a neutral point and the two ends of the scale are at opposite position of the opinion with value (e.g. from strongly disagree (-3), disagree (-2), slightly disagree (-1), no opinion (0), slightly agree (+1), agree (+2) to strongly agree(+3)). According to the "grading system" of project management maturity level assessment by Kerzner [218], different set of questions are mapped into different life cycle phases for project management maturity (i.e. Section 8.3) as summarized in Table 119:

Table 119 Mapping of Questions to Different Life Cycle Phases for PMM [218]

Life Cycle Phases of Project Management Maturity				
Embryonic	**Executive**	**Line Management**	**Growth**	**Maturity**
Q 15	Q 19	Q 21	Q 18	Q 16
Q 17	Q 24	Q 23	Q 20	Q 29
Q 28	Q 27	Q 26	Q 22	Q 30
Q 31	Q 34	Q 33	Q 25	Q 32

Source: Research analysis compilation

The total score for each life cycle phases of project management maturity are computed and summarized in Table 120. According to the "grading system" of project management maturity level assessment by Kerzner [218], the total score of +6 or greater indicates that these evolution stages of maturity have been achieved or at least at a satisfactory stage. Stages with low numbers indicate under-achievement. However, the result may not be always be so straight forward and simple because companies can achieve portions of one stage in parallel with portions of a second or third stage. This means that it is possible for a company to be at the early stage of the “embryonic” phase but entering the maturity level in the “growth” stage. This may not always the case that in times an organization can achieve different maturity level for different maturity stages crossed overtime.

Table 120 Project Management Maturity Level for the Case Companies

	Case Study-1 SYNDES Technologies	Case Study-2 IS Support UNMC	Case Study-3 Company-C
Respondents	• Project Director • Project Manager	• IT Manager • Front Desk Executive • IT Executive	• Executive Director • Operation Manager
Outcome of PMMM Assessment	Embryonic : 2.5 Executive : 2.5 Line Management : 3 Growth : 5 Maturity : 6	Embryonic : 1 Executive : 3 Line Management : 5 Growth : 4 Maturity : 1	Embryonic : 0 Executive : 4 Line Management : 6 Growth : 8 Maturity : 4

Source: Research analysis compilation

To ease the analysis of PMM level, the PMM life cycle phases and its maturity level, along with outcomes and main issue of the three case companies are summarized in Figure 105.

Source: Research analysis compilation

	Level-1	Level-2	Level-3	Level-4	Level-5
PMMM	**Common Language**	**Common Process**	**Singular Methodology**	**Benchmarking**	**Continuous Improvement**
	Basic Knowledge	**Process Definition**	**Process Control**	**Continuous Improvement**	
Life cycle for PMM	**Embryonic**	**Executive Management Acceptance**	**Line Management Acceptance**	**Growth**	**Maturity**
PMM Assessment – SYNDES **Main Issue :** (1) 100 out of 129 bugs are high impact bug; (2) Less than 33.33% of Resource Utilization; (3) 6 out of 10 projects are delayed; (4) 40% of changes to SRS throughout project life cycle	**2.5**	**2.5**	**3**	**5**	**6**
PMM Assessment – IS Support **Main Issue :** 98% of attended front desk IT Requests/Services are not logged into HMS	**1**	**3**	**5**	**4**	**1**
PMM Assessment– Company-C **Main Issue :** (1) 326 tickets (59%) out of 554 tickets violated the resolution SLA; (2) Ineffective and inefficient of Engineer-Ticket Assignment	**0**	**4**	**6**	**8**	**4**

Figure 105 Summary of Project Management Maturity Level for Case Company

8.6.1.1 PMMM Assessment – IS Support UNMC

The outcome of project maturity level of the case company IS Support UNMC indicates that both middle management and operational management are rather weak in recognizing the needs, benefits and what must be done to achieve project objectives and business directives (i.e. +1 embryonic). Besides, IS Support UNMC also demonstrated a moderate lack of visible executive support especially from the front desk executive. This was observed during investigations where basic knowledge is needed to broaden the awareness of front desk executive completing the "front desk cycle flow" by logging-in attended front desk IT Requests/Services into HMS. There always exists a tendency of front desk executives only logging-in problems tickets or calls that requires follow-up; leaving attended IT Services/Requests unrecorded into HMS. This is the biggest detriment to achieving maturity and excellence in project management.

However, the case company gains strong acceptance from the line management (i.e. IS Support Manager and Helpdesk Manager), both managers accept and support project management (i.e. +5 line management acceptances) and agreed the need to smoothen the front desk activities for better customer satisfaction and better handling of helpdesk operation. Despite periodic training and detailed helpdesk operational guideline being in place (i.e. +3 Line Management Acceptance and +5 Growth), front desk support is still far short of completing the front desk cycle for everyday attended service. This was proven with IS Support UNMC being assessed with a low maturity level in recognizing the needs and benefits of what needed to be done in day-to-day front desk routine (i.e. +1 embryonic).

Thus with periodic training schedules, much attention and effort is needed for good understanding of basic knowledge of front desk common processes and operational work flow among the IT staff. In short, front desk executive are unwilling to admit the necessity of change. They do not see how these valuable data could acts as an input to HMS in building knowledge based, which can be retrieved later through intuitive real time reports and dashboards showing the actual performance of the helpdesk support team. Furthermore, with the pool of centralized raw data, HMS is capable of monitoring and managing the overall performance indicators of the helpdesk team such as: peak hour of the day, week and month of the year; the overall resolution rate of respective staff; staff utilization; total unresolved (opened) tickets, speed of resolution by categories, service level agreement (SLA) type, status etc. One of the main reasons of low maturity in the embryonic phase is due to lack of tracking and enforcement mechanism from the line management in dealing with HMS updating inconsistency.

Although it may take months or years to recognize the true impact on the bottom line; these are the foundation bases needed for excellence in project management prior to entering and preparing into the "Growth" and "maturity" phase.

8.6.1.2 PMMM Assessment – SYNDES Technology

When the research team first approached SYNDES in 2012, there was less than ten full-time staff involved in multiples IT projects across different project natures and project deadlines. There were limited resources (i.e. team members) running multiple projects concurrently. An underutilization (i.e. achievement of 33.33% utilization only) of resources was recorded from the exploratory case study due to generic lacking of knowledge in common processes (e.g. +2.5) and common language (i.e. +2.5) among the team members. Both the support team and technical team are lacking in continuous business knowledge and technical knowledge sharing among the team has result in task redundancies, rework, schedule slippage, cost overrun and scope creep.

Due to the structure of the SDM of SYNDES where both technical lead and business lead are lacking of continuous involvement in the project life cycle, both faced challenges of fulfilling project commitment throughout PLC as full-time project involvement is limited. As such, team members lack work commitment, were reluctant to share project/technical/business knowledge among team members and refused to accept project accountability (i.e. observed with +3 in the PMM level-2). Most crucially, QA involvement only existed towards the end of the SDLC prior to sending the product off for user acceptance tests. These ways of "non-continuous" FTE involvements and arrangement has triggered the line management acceptance in personal interest versus project interest. Besides, the tendency of the project team in omitting or preparing brief SRS is the sign of weak process control (i.e. +3 in Level-3 of PMMM) in handling user requirements. The findings showed that the "percentage of changes to user requirement" is a factor contributing to project delay and there was only a 62% chance that project will be delivered on time due to lacking in planning effort.

However, the case company is aware of the importance of project benchmarking for long term continuous improvements (i.e. +5 in the Growth stage and +6 in the Maturity stage). Both the project manager and the project leader has restructured the work processes within the SDM (i.e. adoption of W-Model) to achieve optimum utilization in resource allocation with continuity of FTE involvement throughout SDLC as well as in the broader view of PLC.

In general, much attention and continuous effort is needed at the operational level crossed all IT projects to ensure project activities and procedures adhere to pre-set guidelines and benchmarks in minimizing the risk of schedule slippage, cost overrun and scope creep. The assessment of PMM level of the case study has indeed highlighted the importance of understanding the critical success factor and critical failure factor for effective project management. Since people determine the success and failure of organizations and projects [30], the ability of acquiring and utilizing the right project team within the project life cycle in the SDM is an vital concern in the context of IT project management.

8.6.1.3 PMMM Assessment – Company-C

The PMMM assessment outcome has diagnosed Company-C with strong positive maturity level in level-3 (i.e. +6 Line Management Acceptance) and level-4 (i.e. +8 Growth) of the PMMM model. Company-C indeed has sound process in outsourcing services where helpdesk executive are willingly accept accountability of ticket closure from engineers and ensuring tickets' SLA are meet. These groups of helpdesk executives always race against time to complete tasks and place company interests before personal interests to keep SLA violation to a minimum.

Both project director and operational manager recognize the importance of effective planning in ticket-engineer assignment task; both helpdesk leader and lead engineer requires working hand-in-hand to ensure the least amount of time is used in communicating/coordinating tickets to engineers and thereafter engineers on-site perform service(s). A group of engineers are shared across all project accounts within the same region with different SLA requirements. The line management and top management are geared to excel in project management but the main "warrior (i.e. engineers)" who are performing the outsourcing services refuse to take on accountability of ticket closure (i.e. +0 embryonic) that marked the end of SLA resolution time. Engineers tend to accumulate job sheets ticket closure on a weekly basis and submit to the helpdesk office in batches. This has deterred the helpdesk team from closing attended ticket soonest possible to meet SLA resolution time. In contrast, helpdesk executives are always chasing engineers for ticket closure by phone calls in order to enter details of ticket closure into the vendor tracking system. The achievement of +0 in the embryonic level revealed that the operational team (especially the helpdesk executive and engineers) requires much enforcement, awareness and recognition about the needs, benefits, applications and what must be done as a team for SLA performance achievement.

Company-C are bound to SLA response and SLA resolution for all project accounts, it is important for the case company's management to recognize process improvement as a necessity and must be on a continuous basis. Hence, benchmarking is necessary to embark on this improvement process and the company must decide "what", "whom" and "how" to benchmark. Company-C reported unacceptable performance in SLA achievement (59% SLA violation); as well as ineffective and inefficient in engineer-ticket assignment. This awareness has caused Company-C to adopt Six Sigma practices extending the process improvement into prediction of SLA performance and engineer utilization with forecasted ticket volume. This prediction chart aims to provide an inexpensive and cost-effective approach to pre-allocated appropriate number of dedicated engineers to attend to a projected number of tickets; and is capable of achieving projected SLA performance with a respectable level of resource utilization. This is to keep operation cost lowest possible at the same time achieving an improvement in SLAs performance; as well as being efficient and effective in utilizing the dedicated engineers.

Overall, engineers need to understand the importance of meeting SLA performance as part of the company's business directive; and both middle and top management will continue to seek for long-term continuous improvement for all processes. In short, for one to excel in project management, one must have a strong foundation (embryonic and executive management acceptance) and sound project management practices throughout all the PMMM phases.

8.6.1.4 Summary of PMMM Assessment

As discussed in earlier chapters, Six Sigma initiative is a powerful data-driven and effort-driven approach not limiting its emphasis in quality assurance (QA) but also expanding its capability into quality assurance as well as quality control (QA & QC) with the aid of statistical-base analysis that most other QIMs lack. As such, besides understanding of how to implement and integrate Six Sigma practices/projects into new or existing IT projects, it is important to understand the need of PMMM level assessment. The assessed PMMM level will be mapped onto respective phases of the PMMM life cycle to identify its potential "critical success factors" as well as "critical failure factors" to effective Six Sigma practices integration.

In the earlier section, three case companies had undergone a PMMM assessment and the outcome from the PMMM assessment has been mapped onto the PMMM life cycle explaining how the level of project management maturity affects the project performance of the respective case companies. Besides, the research team extended the analysis into critical failure factors that has contributed to low PMMM level. The combined effect of PMMM level mapped onto respective PMMM life cycle has clearly helped to explain the root cause of respective case company's problem statements. Despite integrating Six Sigma practices into existing QIM, the author has brought the analysis a step further into PMMM level assessment, critical factors in PMMM life cycle to smoothen and increase the success rate of Six Sigma practices' integration process (i.e. to reduce Six Sigma resistance) for better project performance and better customer satisfaction.

8.6.2 Assessment of Project Management Excellence

In the assessment of project management excellence for the three case companies, there are forty-two multiple choice questions (Q35 – Q79) from different components of Hexagon of Excellence adopted from Kerzner [218]. According to the grading system of Kerzner's PM Excellence questionnaire, each question is mapped into different component of Hexagon of Excellence and each answer carries different weightage in pre-determined point-value as shown in Table 121. The interpretation of respective point-category of project management excellence is summarized in Table 122.

Table 121 Mapping and Grading System of PM Excellence

Grading System of Project Management Excellence [218]							Project Management Excellence for Case Companies		
Component	1st Choice	2nd Choice	3rd Choice	4th Choice	5th Choice	6th Choice	Case Study-1 SYNDES Technologies	Case Study-2 IS Support UNMC	Case Study-3 Company-C
Integrated Processes									
Q38	2	2	4	2	4	5	2	2	2
Q39	0	0	1	3	4	5	4	3	3
Q40	0	0	3	4	5	5	4	3	4
Q41	0	1	3	4	5	5	5	4	4
Q42	0	2	2	2	5	N/A	5	4	5
Q43	0	2	4	5	N/A	N/A	2	2	2
Q44	0	5	4	2	0	N/A	4	4	5
Culture									
Q45	0	2	3	5	N/A	N/A	5	3	0
Q46	1	3	4	4	5	5	5	3	4
Q47	1	5	4	0	N/A	N/A	0	4	0
Q48	3	3	3	5	0	4	3	3	4
Q49	1	5	5	3	N/A	N/A	3	5	5
Q50	2	3	4	5	4	N/A	4	4	4
Q51	2	3	4	5	5	N/A	3	3	3
Management Support									
Q52	1	5	5	5	0	N/A	1	1	1
Q53	2	3	5	0	2	N/A	2	2	3
Q54	4	2	5	1	0	N/A	4	2	5
Q55	2	3	5	0	3	N/A	3	3	3
Q56	1	2	2	4	5	N/A	2	2	2
Q57	1	1	3	4	5	N/A	5	3	4
Q58	1	3	5	4	4	N/A	5	3	1
Training and Education									
Q59	1	3	5	5	5	N/A	1	1	1
Q60	0	2	4	5	5	N/A	0	0	0
Q61	0	3	4	5	0	N/A	3	3	5
Q62	2	3	4	5	N/A	N/A	4	3	4
Q63	2	1	2	3	5	N/A	3	2	5
Q64	0	1	3	5	5	N/A	1	1	1
Q65	0	1	3	4	5	N/A	1	1	1
Informal Project Management									
Q66	2	4	5	1	0	N/A	4	2	2
Q67	0	3	4	5	0	N/A	0	3	3
Q68	5	2	3	1	0	N/A	5	2	5
Q69	3	5	4	2	1	N/A	5	4	5
Q70	2	3	4	5	0	N/A	5	4	4
Q71	4	5	3	1	0	N/A	5	3	5
Q72	3	4	3	5	N/A	N/A	3	3	3
Behavioral Excellence									
Q73	1	2	4	5	0	N/A	5	2	2
Q74	3	1	5	2	0	N/A	1	1	1
Q75	3	5	5	5	4	N/A	5	3	3
Q76	2	2	2	5	3	N/A	2	2	2
Q77	3	5	5	1	5	N/A	5	1	3
Q78	5	4	4	1	2	N/A	5	2	1
Q79	5	2	2	1	1	N/A	4	5	5
						TOTAL	**138**	**111**	**125**

Source: Research analysis compilation

Table 122 The Interpretation of Project Management Excellence [218]

Points	Interpretation
169 – 210	The company compares very well to the companies discussed in this text. The company is on the right track fir excellence, assuming that the company has not achieved it yet. Continuous improvement will occur.
147 – 168	The company is going in the right direction, but more work is still needed. Project management is not totally perceived as a profession. It is also possible that the organization simply does not fully understand project management. Emphasis is probably more toward being non-project-driven than project-driven.
80 – 146	The company is probably just providing lip service to project management. Support is minimal. The company believes that it is the right thing to do, but has not figured out the true benefits or what the executives should be doing. The company is still a functional organization.
Below 79	The company has no understanding of project management, nor does it appear that the company wishes to change. Line managers want to maintain their existing power base and may feel threatened by project management.

The total points for these 42 questions are collected, computed and tabulated on the right side of Table 121 and the summary of each case company's evaluation on project management excellence are summarized according using interpretation of Project Management Excellence in Table 122. The three case companies were group under the same category of 80-146 points (i.e. 138-points for SYNDES, 111-points for IS Support UNMC 125-points for Company-C) where the management support from the IT management team in project management excellence is minimal. The case companies are probably just providing lip service to project management and this can be justified where little support (i.e. low rating for Q59 – Q65) were captured for the component of "training and education" in the context of project management (Table 121).

In view of the importance of investing in project management self-development is crucial for long-term growth and retention of personnel [218], experience project managers and project leaders understand the need of continuous establishing project management training programs amongst the team members to acquired necessary interrelated project management skills and knowledge to groom respective team members to excel in project management. However, the possibility of team members successfully attending scheduled training or IT-related education is always dependent on the progress and urgency of the undertaken project. In most cases, the scheduled training or education needs to give way in exchange of project benefits such as on-time delivery, within budget and within scope. The case companies are still a functional organization.

Even though the three case companies demonstrated a good understand in the "growth" phase of maturity level in the life cycle of PMM (i.e. scoring of point 5, 4 and 8 for SYNDES, IS Support UNMC and Company-C), the case companies understand that project management excellence can be achieved when all employees simply understand their job descriptions and job responsibilities. In short, the achievement of project management excellence is greatly depends on the pool of available resources (i.e. team members, project leaders, project managers) of the companies. Thus, awareness and understanding of project management excellence should be viewed from company-wide perspective involving every team member from the start of the project life cycle.

Nevertheless, a strong foundation of respective case companies' project management environment via mixture of formal and informal of project management (i.e. high score in the sub-component of "informal project management" for all three case companies) in different sub-operational work flows will prepare and lead the case companies moving towards the next level of project excellence in time to come.

In summary, it is an important awareness amongst the SMEs in the IT industry regarding the assessment of project management excellence as a means of continuous improvement where it is through implementation that excellence in project management is achieved. Besides, the level of project management excellence for years to come should be extended beyond experience and success. Since Six Sigma initiative is an effort-driven approach, the level of commitment of project management excellence for all Six Sigma projects in the case companies is important to establish a continuous streams of process improvement in long term.

Most importantly, project excellence is ongoing; it never stops and it can always be better. The journey to project excellence is never easy and it is an long term effort involving every team members recognizing the need for excellence; recognizing where respective company want to end up; ability in identifying the obstacles which must ne overcome; thereafter planning out the journey in long-term and short-term. Organizations excellent in project management are those that create an environment in which there exists a continuous stream of successfully managed projects and where success is measured by what is in the best interest of both the company as well as the project (i.e. customer).

8.6.3 Summary of Project Management Maturity Level and Project Management Excellence

As discussed in the earlier section, companies mature in project management may not be excellent in project management; and for any company to be successful and survive, the only way is to be competitive and meet market needs on a timely basis. Therefore, the continuous streams of successfully managed projects are the best interest of the company.

When any company developed mature system and processes in the context of IT project management, work is accomplished with minimum scope changes and processes are designed with minimum disturbance to ongoing business. Alternatively when any company achieved project management excellence, scope creep is expected and planned for. Positive cultures such as project managers are encouraged to make decisions based on sound business judgement are developed and encouraged open doors competitions.

The effort to achieve maturity and excellence is a long term commitment and should not be left to chance or to trial and error. Instead, the case companies should lay down a structured process whereby the team members can understand, follow and share. In short, the project manager must be capable to define (with some reasonable degree of accuracy) what constitutes project success, project management maturity and project management excellence. Today, the definition of success is measured in terms of primary (i.e. on time, within cost; at the desired quality) and secondary factors (i.e. accepted by customers, customer allows you to use the customer name as a reference). These primary and secondary factors can be addressed when Six Sigma practices are integrated into existing processes to smoothen and increase the success rate of successfully managed projects which were discussed in three case companies in Chapter 5, 6 and 7 respectively.

8.7 The Roadmap Framework

In order to perform exploratory case study on three areas of IT industry to find out the feasibility of Six Sigma implementation and integration to existing processes to unlock the potential of Six Sigma for the three case companies, a broad list of potential “business successes” was recorded and the data has proven the benefits of the Six Sigma system. In view of 97% of Malaysian IT companies already having adopted a QIM, it is important to explore the breadth and flexibility of Six Sigma and how it can integrate with existing QIMs to bring about a greater impact on a business’s competiveness and bottom-line. Most importantly, it is the detailed “statistical thinking” paradigm of action and learning based on processes, variation and data analytical methods that give evidence for QA and QC perspective as compared to traditional approach of QIM.

The final roadmap of Six Sigma Implementation framework for implementation and integrating in Malaysia IT companies in the field of IT Project Management (Figure 106) was formed by integrating findings from the following logical sources:

1) A series of comprehensive literature reviews covering various QIMs in the IT and non-IT industries; the similarities versus differences, advantages and limitations, critical success factors, critical failure factors for each QIM (Chapter 2, Chapter 3).
2) A collective outcome of literature reviews and business related articles/magazines of Six Sigma implementation and adoption in different sub-areas of IT industry (i.e. IT Products, IT Services and IT Processes) (Chapter 2).
3) The extended literature analysis to understand the interrelationship and correlation between IT Processes, IT Products and IT Service; and how each business areas affect quality and the importance of IT Processes as a vital segment to the quality of IT Products and IT Services (section 8.1).
4) The high level potential business improvement opportunities assessment of Six Sigma implementation and integration (Section 8.2.1).
5) The review of key questions criteria to Six Sigma practice(s) and project(s) assessment (Section 8.2.2).

6) Decision criteria to implementing and integrating Six Sigma into existing processes (Section 8.2.3).
7) The Life Cycle Phases for Project Management Maturity and Project Management Excellence (Section 8.3).
8) The literature review and online questionnaire findings of Kerzner's project management maturity level assessment and project management excellence assessment of organization's project management strengths and weaknesses (Section 8.6).
9) Critical success factors and critical failure factors gathered from findings and results analyzed from questionnaire (Section 8.4), Kerzner PMMM (Section 8.6.1) and Kerzner's Project Management Excellence (Section 8.6.2).

Source: Research analysis compilation

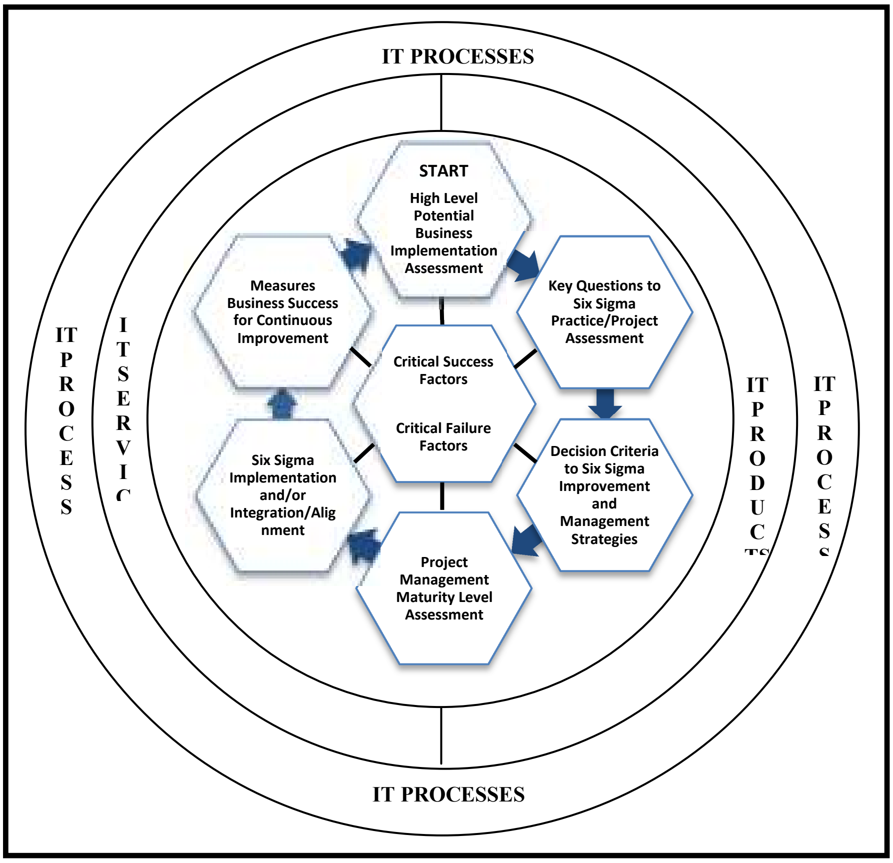


Figure 106 Roadmap Framework of Six Sigma Practice and Project Implementation and Integration

Table 123 is a step-by-step guide to the roadmap framework for Six Sigma practice and project implementation and integration. In giving the Malaysian IT industry a general guide to Six Sigma best practices, the study compiled and synthesized different findings and outcomes from the exploratory case studies, questionnaire, literature reviews, expert viewpoints, guided by the author's experience gained throughout the research duration and understanding of what work bests for the roadmap framework formulation. These sources represented the collective knowledge needed to construct the roadmap framework of Six Sigma implementation and integration to existing processes in the Malaysian IT Industry to set broad goals, directions and constant attention to both long-term growth and continuous improvement.

Table 123 Step-By-Step Guide – Roadmap Framework

A) Step-1: High Level Potential Business Improvement Opportunity Assessment

- **Current Quality/Service Performance Evaluation** – To draw conclusion about current performance to decide if critical improvement and changes are needed
- **Need for Financial and Competitive Opportunity** – To decide Six Sigma projects which has significant impact in the early success as well as financial benefits and competitive opportunity
- **Long Term Improvement and Short Term Focus of Result/Outcome** – To drive for long term improvements where short term focus of result/outcome of Six Sigma initiatives is reflected
- **Targeted Percentage of Performance Improvement** – To decide a "target level of improvement" to ensure effort and time spend on Six Sigma initiatives is result-focused and consistent with management's expectation

B) Step-2: Key Questions to Six Sigma Practices and Project Assessment

- **Availability of Data & Fact (Present and History)?** – To ensure measurement metrics are define
- **Availability of Key Role Team Member (High Potential staff)?** – Important to select the high-potential staff within the same IT industry and not an outsider
- **Facing Challenging Processes?** – To identify the bottleneck which slow down the entire work flow (i.e. to have focused-assessment on challenging processes)
- **Commitment from Top Management & Business Leaders?** – To foster ability of cross-functional as well as top-down hierarchical management to explore new ideas for breakthrough improvements
- **Unacceptable Variations in Current Output Performance against Target Set?** – To laid down target set so that a benchmark of performance variation can be diagnosed throughout the project life cycle
- **Ways for Improvement and to be Closer to Perfection?** – Important to strike a balance between push-and-pull resulting in broad business success

C) Step-3: Decision Criteria for Integration of QIM with Six Sigma Practices and Projects

- To assist the team to define and quality measurement metric for Six Sigma measurement. This is to avoid: (1) Drawing false conclusion based on incomplete analysis; (2) Drawing correct conclusions but not backed up with statistical validation; (3) Lack of optimization in decision process

D) Step-4: Project Management Maturity Model

- Important to know respective company's maturity level of project management commitment to better prepared in dealing and handling potential critical failure factors

Source: Research analysis compilation

Therefore, the framework provide a general overview and fundamental kick-start guidance to IT companies seeking and exploring the potential of Six Sigma as a means of continuous improvement; and how Six Sigma can be expanded and extended to include secondary external factors that are critical to successful QIM implementation in the context of the Malaysian IT industry. The roadmap framework also aims to understand the interrelationship and the correlation between IT Processes, IT Products and IT Service; and how they affect quality; and thereby get closer to identifying the importance of IT Processes; which is truly a vital segment to the quality of IT Products and IT Services.

One of the most remarkable breakthroughs in this study is the positioning of IT Processes as the key vehicle of success to realize the end product of IT Services and IT Products. The ability to properly manage one segment of IT Process will result in overall performance improvements ranging from output quality, delivery, satisfaction and sustain from improvement in competitiveness. The efforts of Six Sigma as a new QIM or integrating with existing QIM has proven to be a convincing phenomenon particularly in the IT industry where mastering IT processes is not just a necessary evil but actually a way to build competitive advantage in delivering quality and value to customers and foster competitiveness among the competitors.

8.8 Summary

This chapter gathered the views, facts, argument synthesis as well as explanatory summaries from a number of sources and draw relationships between them. Most importantly, the detail process of Six Sigma framework development and conceptualization for implementation and integration in Malaysia SMEs IT companies are openly discussed and synthesized from the exploratory execution of three case companies to provide a general overview and guidance in key areas considerations prior Six Sigma implementation or integration.

Besides, the framework provides a general guide to Malaysian SMEs IT companies exploring the potential of Six Sigma as a quality improvement initiative in three business areas of IT Processes, IT Products and IT Services. Furthermore, the framework also take into consideration about the implication of critical success factor (CSF), critical failure factor (CFF), project management maturity level (PMM) and project management excellence to policy and practice; as well as their limitations. The framework was a result outcome based on collected data and lesson learnt during the DMAIC or DFSS process of the three case companies in the duration from August 2012 till March 2014.

Chapter 9 Conclusion, Contribution, Implication and Direction for Future Research

9.1 Introduction

This chapter concludes the current study by summarizing and mapping the research findings discussed in the synthesis summary chapter (Chapter-8) against the research objectives and research questions. The outcomes of the mapping led to the development of a roadmap framework capable of providing a general overview and guidance on the key areas of consideration when implementing or integrating Six Sigma into Malaysia's IT industry. The framework takes into account the implications of critical success factor (CSF), critical failure factor (CFF), project management maturity level (PMM) and project management excellence to policy and practice; as well as their limitations. Some thoughts on the directions for future research in this area are proposed and these are presented at the last section of the chapter.

9.2 Mapping on Research Objectives and Research Questions

9.2.1 Mapping on Research Objectives

This section outlines the mapping of the research objectives (RO) and summarizes the principal findings from current study. This study involved a feasibility analysis of Six Sigma implementation in Malaysia's IT Services, IT Products and IT Processes. Following is a list of research objectives addressed in this study:

1) To understand and review current QIMs adoption amongst IT organization in Malaysian and to investigate the awareness of Six Sigma implementation among IT Specialists.
2) To review and identify decision criteria of selecting a suitable and applicable QIMs for IT Company.
3) To identify root causes of project delivery obstacles especially in the exploratory case study.
4) To conceptualize and develop Six Sigma implementation and integration framework for adoption in Malaysia IT companies in the field of IT Project Management.

The investigation adopted exploratory case study approach with three Malaysia IT companies. Each company represents the field of IT Products, IT Services and IT Processes respectively following the "Six Sigma Way" by Pande at al., [152]; as such the development and application of a suitable roadmap framework as a deliverable in these research projects were achieved. The study utilized semi-structured interviews, questionnaires, observation, on-the-job training, document analysis, historical records analysis, correlation as well as ethnography.

The detailed steps of each Six Sigma DMAIC or DFSS phase were recorded, summarized, tabulated and analyzed. A collection of frameworks, roadmaps as well as flow charts were formed on the basis of comprehensive literature reviews, case study exploration and primary data gathering via the chosen methodology. The time frames of the exploratory case studies undergone Six Sigma implementation or integration with existing QIM is running in parallel as follows:

- SYNDES Technology (IT Product and IT Process) : August 2012 to September 2013
- IS Support UNMC (IT Service and IT Process) : August 2012 to September 2013
- Company–C (IT Service and IT Process) : November 2012 to March 2014

As a continuous effort to introduce and develop roadmaps, frameworks and flow charts of different revisions were carried out throughout the case study duration and a final evaluation was performed based on the cumulative findings from the three case studies; as well as upon collective literature reviews from articles, journals and conference publications. The following presents the mapping of each research objectives against various findings and their respective conclusions:

A) RO1 objective mapping**:** To understanding and reviewing of current QIMs adoption of IT organizations in Malaysia and to investigate the awareness of Six Sigma implementation among IT Specialists

The pattern and trend of QIM adoption among the IT SMEs companies in the past, current and for the future has been investigated, documented and collated through qualitative and quantitative approaches. A listing of the most adopted and implemented QIMs in Malaysian IT organization was compiled from comprehensive literature reviews and was used in the survey study. The result suggests a need to raise awareness about the shift of QIM from quality assurance to quality control can be achieved through the followings:

- implementing a QC approach of QIM
- integrating another potential QIM into existing QIM

The following findings were drawn based on the results discussed in Chapter-2:

A) The analysis revealed that ITIL followed by Six Sigma are the two major QIMs being implemented in most IT companies currently; with ISO facing an obvious decreasing popularity among IT companies due to the increasing competition of money, time and paperwork required for ISO efforts. Six Sigma and Lean-Six Sigma are the two preferable QIMs gaining much attention in the future.

B) The adoption of QIMs in Malaysia's IT industry in the past, current and future showed that IT companies are skewing away from the traditional method of quality assurance to quality control in search of business excellence and long term continuous improvement.

C) There exists potential awareness of QIM migration among the IT specialists by integrating existing QIM with another complementing QIM.

D) There is a lack of awareness of Six Sigma implementation among the non-Six Sigma supporters of IT specialists. However, a consistent, coherent and positive outcome of Six Sigma to be adopted in the near future was recognized and acknowledged between these two groups (i.e. Six Sigma and non-Six Sigma supporters). Hence, there is a a strong positive awareness of Six Sigma among the existing successful users; but more effort should be focused on strengthening awareness among non-Six Sigma users about the potential of Six Sigma.

E) A list of quantitative and qualitative outcomes as well as the reasons for QIM adoption in the Malaysian IT industry are discussed in Section 2.2; i.e. "Commonly used tools and techniques in QIM implementation"; "Common measurement metrics in the Malaysia's IT industry"; "Primary and secondary measureable benefits of QIM adoption"; "Common practice of project authority in the Malaysia's IT industry"; "The need and pattern of pre-QIM Training in the IT industry" and "The impact of non-existence of QA Department".

B) **RO2** objective mapping: Reviewing and identifying decision criteria of selecting a suitable and applicable QIM for IT Company

A QIM roadmap for IT-related (BOOTSTRAP, SPICE, CMM/CMM-I, ISO, ITIL, PSP and Six Sigma) and non-IT-related (TQM, TOC, Lean, Six Sigma, Lean-Sigma, ISO) businesses was derived to provide a clearer and easier way of selecting a suitable and applicable methodology that fits an organization's objectives and culture. The roadmap summarized the theory-based roadmap into simple picture representation showing the mapping of different QIMs in the IT and non-IT industry (Section 2.1.3).

The decision criteria of selecting a suitable and applicable QIM are systematically structured into a hierarchy model addressing the core emphases of QIM and cause-and-effect relationships which focused on the fundamental primary and secondary effects (through the if/then statement) of the philosophy of each improvement methodology. This roadmap provides a clearer and easier way for IT and non-IT companies in finding the appropriate methodology in accordance with their respective business needs and business nature.

C) RO3 objective mapping**:** To identify root causes of project delivery obstacles especially in the exploratory case study approach

The research outcomes drawn from the relationship between product life cycle, project life cycle and SDLC (Section 8.1) helped in gauging Six Sigma tools and techniques into different stages of project life cycle and SDLC to provide a holistic view in root cause identification. Each case study is unique in its objectives, directions, deliverables, quality measurement metrics etc.; and the tools and techniques applied in each stage of the project life cycle and SDLC for root cause identification should be unique too. This awareness is a crucial discussion topic in the exploratory case study approach as incorrect root-cause identification will lead to incorrect quality measurement metric being identified.

Hence, the Six Sigma way of identifying root causes by gauging tools and techniques into different stages is capable of addressing project-related questions including project delivery obstacles. This Six Sigma way of root-cause identification has been proven and the details are discussed in Chapter 5, 6 and 7.

D) RO4 objective mapping: To conceptualize and develop Six Sigma implementation or integration framework for adoption in Malaysia IT companies in the field of IT Project Management

The framework aimed to provide a general guide to Malaysian IT companies exploring the potential of Six Sigma as a quality improvement initiative in the business area of IT Processes, IT Products and IT Services has been successfully conceptualized and developed based on a series of research activities discussed in Chapter-8.

The research outcomes gathered and recorded from the literature reviews and exploratory execution of three case studies from the Malaysian IT SMEs has proven Six Sigma a reliable, predictable and effective quality improvement initiative. Its' unique feature of data-driven and statistically based problem-solving approach has taken the quality management a step further by measuring the quality outcomes against the benchmark and project target instead of focusing in procedural activities conformance.

The framework can be viewed from two broad perspectives of understanding the interrelationship and correlation between IT Processes, IT Services and IT Products; and how the assessment criteria affected quality. Several criteria of assessment were evaluated and presented in section 8.2 to section 8.6 as a result of collective literature reviews and research outcomes gathered from the exploratory execution of three case studies. The framework was developed based on the collected data and lesson learnt during the DMAIC or DFSS process. The collective outcomes of RO1, RO2, RO3 and RO4 strongly support the hypothesis of Six Sigma to be the next in-line QIM in Malaysia's IT industry.

9.2.2 Mapping on Research Question

Research questions (RQ) are a set of pre-requisite components to define the whole process of the exploratory case study and to guide the arguments and inquiry towards the accomplishment of framework development. Following are summary of the research questions aiming to organize and disseminate the research objectives of this study.

- **RQ1: How could the "project quality" be addressed and measured?**

It is always a debatable question on how to address project quality. Project quality should be addressed from the view point of customers about their expectation in terms of quality from the final deliverable. It is important to describe acceptance criteria and quality attributes in measurable and quantifiable terms so as essential strategy and information can be put into quality plan for execution. Having the project quality addressed is just the start of a project quality journey, the next step is to measure or quantify the processes and outcomes which provide acceptable and high-quality deliverables.

Project quality can be measured in two approaches of quality assurance and quality control as discussed in Chapter-2. This study adopted the Six Sigma way of quality measurement which combines both QA and QC approaches to identify defects in the IT products or IT services before product release or service implementation. This approach form the basis for scoping the project and planning for end products activities required to meet the expectations.

- **RQ2: What are the possible quality metrics to benchmark for future IT projects in reducing the learning curve and yet improving the project quality?**

A quality metric is a verifiable measure stated in either quantitative or qualitative terms. Quality metric is the key to capture performance of how a process, product or service is being done relative to a standard or benchmark to allow comparisons and support for business strategy. The identification of quality benchmark or standard is often a challenging task and most of the time the quality metrics of IT industry lies in the category of "defect density", "customer problems", "customer satisfaction" and "mean time to failure". Others benchmarking quality metrics are discussed in Section 2.2.4.4.

Following are the summarized benchmark quality metrics gathered from the three case studies and details are discussed in Chapter 5, 6 and 7:

1) SYNDES Technologies. (1) On-time software release; (2) Number of reported bugs after release; (3) Testing defection; (4) % Changes to SRS; (5) FTE Utilization.
2) IS Support UNMC. (1) Email notification of receipt and acknowledgement within one working day; (2) Immediate attention to AV related issues and resolution within 10 minutes; (3) Front desk throughput (i.e. queue waiting cycle time); (4) Incident satisfaction level and (5) HMS Utilization.
3) Company-C. (1) 95% SLA conformance; (2) Ticket closure within SLA duration; (3) SLA resolution rate; (4) SLA response rate; (5) SLA response and SLA resolution expiry computation defection; (6) FTE Utilization and (7) Engineers throughput.

- **RQ3: What are the driving factors for scope creep, project delay and project cost overrun?**

One of the main drivers for scope creep, project delay and project cost overrun is lack of project planning. Project planning is one of the most important and critical stage in the modern software development process because it defines the project based on the requirements gathered. Any IT project without a solid blueprint of the project plan will most likely jeopardize the entire process and eventually result in project failure. The integration of various plans aspects such as 'detailed requirements definition", "mapping of requirement definition items into project schedule" and "project/modular quality delivery" which has major impact on the final project performance delivery are discussed in SYNDES case study in Chapter-5.

- **RQ4: What are the problems and challenges anticipated during project life cycle for IT Product, IT Process and IT Services?**

A list of key issues and challenges anticipated in IT process improvement are presented in the discussion topic of “resistance factor” in Section 2.2.4.9. However, following are listing of other challenges gathered from the exploratory case study (not in the order of importance):

1) Lack of clarity in the scope of the project
2) Lack of thorough understanding of the data dynamics and dependencies involved in data recovery
3) Inappropriate approach or design in executing the study
4) Incorrect and inappropriate assumptions in formulating business continuity and disaster recovery plans
5) Unwillingness of project manager or project leader to release team member for training
6) Team culture and project culture

There are no one-size-fits all approach to implement IT projects. Project managers and project leaders need to adapt relevant standards and best practices to suit respective organizational culture and requirements. Resolving the relevant issues and challenges appropriately based on organizational context helps in establishing a sustainable quality program and in enhancing an organization’s PMM maturity.

- **RQ5: What are the activities involved in IT Project Management?**

The software project management (SPM) framework identified by Schwalbe [30] includes the key competencies concerned during the project management process. The SPM framework identifies nine knowledge areas which describe the key competencies that project managers must develop. These areas are categorised as core and facilitating functions. The core functions, namely scope, time, cost and quality management lead to specific project objectives and are supported by the facilitating functions. The facilitating functions represent the means through which different objectives are to be met and include human resource management, communication, risk, and procurement management. Last but not least, the project integration management as well as the tools and techniques are stretched across all these knowledge areas to assist team members and project managers in carrying out the core and facilitating functions.

Typically in the SYNDES case study, the core functions are analysed in detailed during the root-cause analysis stage to improve productivity, leading to better internal coordination, better control and utilization of human resources, shorter development times, higher quality and increased reliability, lower cost, higher worker morale, improve customer relationship and customer satisfaction. Therefore, it is important to understand the respective business nature and business routine prior to identify important activities for improvement.

9.2.3 Mapping on Research Hypotheses

There are two specific, clear and testable predictive statements of research hypotheses about the possible outcome of this research study which were defined based on a population of case companies involving different IT-related business. The two hypotheses addressed in this study are:

1) **Hypothesis 1 (H1):** This study is based on the hypothesis that implementing Six Sigma as a QIM in the field of Malaysian IT industry will improve the overall project quality and customer satisfaction.
2) **Hypothesis 2 (H2):** If there exist a currently adopted QIM, integrating Six Sigma into existing QIM will improve the quality of IT Products, IT Services and IT Processes.

The process of Six Sigma implementation and integration (H1 and H2) into the case companies involved a series of complex, thorough and rigorous activities at different DMAIC phases. The capability of Six Sigma in achieving and sustaining operational and service excellence are demonstrated with recorded measureable benefits (i.e. intangible and intangible) from the case companies in various aspects of project management related activities are discussed in Chapter 5, 6 and 7:

A) SYNDES Technology (IT Product and IT Process)

- **Tangible result(s):** Resource Utilization improved by 200%; SRS Changes improved by 87.5%; Establish highly motivated team; Management ability to spend 50% more time exploring business opportunity; Deliverable quality improved by 82.17% and Team Productivity increased by 50%
- **Intangible result(s):**Adoption of new SDM of W-Model; Establish highly motivated team; Both business and technical knowledge among business lead and technical lead has been reduced; Mapping of project activities into project schedule; Better team motivation and team spirit

B) IS Support UNMC (IT Service and IT Process)

- **Tangible result(s):**Queue Waiting Time improved by 41% (improve by 2.5 cycle); Front Desk Officers availability increased by 42%; HMS Utilization improved by 92%; Achievement of Incident Satisfaction Survey of 94%; Customer Satisfaction of 94%; Front Desk Officer Idle Waiting Time reduced by 72% [249]
- **Intangible result(s):**Establishment of positive work culture

C) Company–C (IT Service and IT Process)

- **Tangible result(s):**Achievement of 100% computation of ticket expiry time; Achievement of better FTE utilization (72%); SLA performance improved by 28%; Operating cost per month improved by 37.5%; SLA violations improved by 28%; Accuracy of SLA expiry computation improved by 20%
- **Intangible result(s):**Creation and adoption of resource utilization prediction chart improve project planning; Establishment of ticket closure by engineer

9.3 Research Contributions and Implications

This study provides significant contributions to the IT project management knowledge, QIM implementation and integration in the IT sector and other external factors which may directly or indirectly affecting the success rate of QIM implementation in Malaysia.

Through rigorous literature on QIM adoption in the field of IT and non-IT industry, there were very few case study research and publications of Six Sigma in the Malaysian IT industry. Hence, the main outcome of this research is to perform feasibility analysis of Six Sigma implementation and integration in Malaysia for IT Services, IT Products and IT Processes. Following are the list of contributions from the current research study:

A) A series of extensive theory-based literature reviews has shown a lack of success stories of Six Sigma implementation and integration from the Malaysian-based IT companies. Thus, this research study creates ample research opportunities of exploring how Six Sigma can be implemented and integrated as a QIM into the IT industry.

B) IT organizations in Malaysia are indeed looking for a long term improvement methodology which promises short term outcomes. Most importantly, majority of the surveyed companies are ready for Six Sigma implementation as these companies have been applying the relevant tools and techniques related to Six Sigma. This concludes a positive insight about the potential adoption of Six Sigma as a new QIM or integrating existing QIM with Six Sigma is possible. The feasibility of Six Sigma as a QIM in IT industry was theoretically, qualitatively and quantitatively proven.

C) The achievement of the evolution of QIM in Malaysia's IT industry in the past, current and future clearly demonstrated a shift of QIMs patterns and trend from quality assurance (QA) to quality control (QC) or both (i.e. QA and QC). This can be achieved by adopting a QC approach in QIM or by integrating two or more QIMs into yield a more powerful and effective QIM addressing many of the weaknesses and retaining most of the strengths of each QIM.

D) A theory-based roadmap of a hierarchy model comprising core emphases and cause and effect relationship of QIM was proposed and evaluated against the case companies. Values of a specific improvement methodology are compared with the values of the organization to allow diagnostic mapping questions concentrated on the primary and secondary effects to help organizations to identify the likely methodology to be selected. This way of representing decision criteria by combining the picture representation of QIM selection without neglecting the importance of detailed theory-text description make the QIM selection process clearer, easier and useful for both IT and non-IT organizations. This roadmap provides a clearer and easier way for companies which have decided to embark on a quality journey to know the best or at least a more obvious methodology that fits the organization's culture.

E) This study has contributed to a new understanding of QIM migration awareness among the IT specialists about the shift of integrating existing QIM with another potential QIM. This shift of integrating two or more QIMs not only retained existing cultures and norms; it also allows the organizations to achieve a higher level of maturity in quality management. Furthermore, evidence from practitioners about other combinations of QIMs integration has proven this (Section 2.3) and is not limited to the field of IT, but also in banking, healthcare, engineering, internet service provider etc. Despite seeking for a new comprehensive top-down approach (QA and QC), IT companies may opt for integrating existing QIM with another QIMs which enforces quality control and continuous improvement.

F) Another new understanding of the interrelationship and correlation between IT Products and IT Services within the boundary of IT Processes outlined the importance of IT Processes truly a vital segment to the quality of IT Products and IT Services. This new perspective thinking supersedes the misconceptions among IT team members being overly focused and emphasizing solely on the output (i.e. It Product and IT Service) and neglecting the operational IT processes while developing the end product. The fact that Six Sigma being the ‘process improvement methodology” mutually fits into IT Processes. Adoption or integration of Six Sigma into IT Process activities was tested and evaluated in the case companies which have shortened the learning curve.

G) A roadmap of Six Sigma implementation and integration framework in the Malaysia IT industry was developed. The framework places great emphasis on “how to do it” as well as “what to do”. The framework can be viewed from two broad perspectives with the highest level outlined seven criteria of assessment and the second level described how these assessments can be carried out with the aid of flow-chart, roadmap, question mapping and set of guidelines. Different sets of roadmap to key questions in graphical representation were achieved to better handling of “how to” and “what to do” questions. The core of this framework is the identification and measurement of quality measurement metric (QMM) which presented in a decision-criteria flow chart manner catering for new Six Sigma implementation as well as integration of existing QIM with Six Sigma. In general, most QMM are explained in text-based description and is limited to a single QIM of either QA or QC approach independently. This way of presenting QMM decision-criteria flow chart catering for different combination of QA and QC has not been widely explored. This framework aims to serve as a ‘handbook’ to Malaysian IT companies which provide a step-by-step kick-start guidance to IT companies seeking and exploring the potential of Six Sigma initiatives to drive operational excellence and perfection. Most importantly, the framework provide a general overview and fundamental guidance from the perspective of “organizational” and “business” level if a “renewal” is needed and if the “benefits” are justified prior to investing money and resources into Six Sigma initiative. Furthermore, the ability to define "measureable" quality metric(s) for Six Sigma implementation and integration is the key success factor in this study as the definition of such metric(s) has great impact on root-cause analysis as well as Six Sigma computation. Incorrect definition of "measureable" quality metric(s) will cause mis-leading and mis-understanding in the "Define" phase (i.e. root-cause analysis) which will further complicate the suggestion of action plan(s) as well as affecting the progress of other activities in the following DMAIC phases. As a result, the ultimate objective to reduce existing defect rate to a targeted defect rate (i.e. the defined measurable metric(s)) for better performance is deemed difficult to achieve; and the recorded improvement outcome(s) are not justified with time spent and resources invested into this initiatives for maximum return on investment. Even though when the Six Sigma initiative does not achieve the targeted defect rate, the list of implemented improvement(s) will still be contributing to day-to-day quality and process improvement. The reason behind this is Six Sigma is not only seen as a function for metric measurement, it is also seen as a methodology as well as a management system and approach for overall organizational quality improvement. Despite the mentioned key points, the framework also takes into consideration that attention should be given to the respective company's project maturity level, critical success factors as well as critical failure factors when implementing and integrating Six Sigma. The incorporation of these discussed considerations areas (i.e. from Section 8.7) into the framework is indeed capable of serving the needs of SMEs in the Malaysia IT industry to embark on Six Sigma in a more effective and productive manner by incorporating measurable quality standards and quality measurements into their business operations.

H) One of the primary contributions from the exploratory case study is the ability of Six Sigma in handling and predicting resource utilization in the context of IT project management as describes below:

- The Six Sigma approach has enabled SYNDES to explore the importance of project planning and customizing the software development methodology (SDM) to better manage its scarce resources, control and track IT projects (Section 5.5.2). The customized SDM has been tested concurrently in three separate projects within SYNDES. Thus, SYNDES achieved optimum resource utilizations through the SDM customization as well as the establishment of a highly motivated project management team (i.e. reliable, responsible and trustworthy) in handling IT projects. More positive secondary impacts of crossed departmental business knowledge and technical knowledge sharing; SRS changes handling etc. are discussed in Section 5.5.2.

- Company-C has explored the other side of resource utilization in the IT Process and IT Service section. The outcomes from the Six Sigma analysis has driven Company-C to adopt "dedicated engineers" instead of sharing a common pool of engineers across all project accounts. The formulation of the prediction chart allowed the management team to better forecast ticket volume to better manage, control and track SLA performance. This chart has been tested with at least six months of data and the accuracy is highly significant (Section 7.5). The outcome of the prediction chart has successfully raised awareness among the management team whereby the "optimum point" of resource utilization has a significant impact in SLAs performance, resource utilization and operational costing. These trio-fact findings have proven to be useful and others benefits gained from the Six Sigma approach are saving in operational cost, improvement in operational procedure and etc.

I) Exploratory case study with IS Support has revealed "culture" as one of the main resistant failure factor affecting project performance in the context of project management. This finding has led the research team to expand research direction into PMMM assessment which addresses how culture elements have impact in project excellence and project performance.

9.4 Research Limitations

While this research study contributes to knowledge, awareness, guidance and assistance of QIM implementations and integration, it also gives rise to some limitations that could affect the findings of this study. Most importantly, these limitations raise further questions and research opportunities.

One primary limitation noted was the sample size used to evaluate the quality improvement initiatives in the Malaysian IT industry. As the sample was relatively small, there may be a lack of validity and reliability in the results obtained in order to represent the view of entire Malaysian SMEs in the IT industry. However, the strong sampling distribution gathered from a variety of IT businesses among vast groups of first-line management level personnel represents a significant fraction of representative views from the IT industry and is deemed valid. The research team would definitely have preferred to achieve a greater sample size involving more SMEs from different IT background to better represent overall findings collected from the survey.

Although the roadmap to QIM selection is a combination of the picture representation without neglecting the importance of detailed theory-text description using the if/then statement, it does not address all possible types of QIMs such as Benchmarking, Balanced Scorecard, COBIT etc. In view of time restrictions, this selection roadmap may be superseded after a period of time when an organization has reached a higher level of maturity and the needs of QIM vary over time. However, this QIM selection roadmap can still serves as a fundamental knowledge and overview of selecting a suitable and applicable methodology that fits an organization's objectives prior to investing valuable time, money and resources.

The study aims to carry out exploratory case study of Six Sigma implementation and integration in the three main business areas of IT industry in the Malaysian context of project management; only one case study per business area was achieved (i.e. Company-A on IT Service, Company-B on IT Product and Company-C on IT Process and IT Service). The research team preferred to have more case studies conducted for each IT business area; however it was not possible and permissible within the timescale. Performing data analysis and getting enough data to comparatively measure core business processes of one case company can take months or even a year of effort. Measurement is probably the biggest "investment" any case company makes in its Six Sigma initiatives but an emergent paradigm shift of QIM implementation not limiting to QA only but QA and QC can be achieved. A suitable and flexible QIM can help companies formalize a systematic well-rounded approach covering top management all the way to the operations level in handling day-to-day tasks.

The "Control" phase in DMAIC was also not achieved in the case studies except for the IS Support case study. The control phase is the end of the DMAIC, but it is really the beginning of the sustained improvement and integration of the Six Sigma system. The case companies would explore both the short and long term challenges of sustaining Six Sigma improvement and building all the concepts and methods of step 1-4 (i.e. DMAI-C) into an ongoing, cross-functional management approach. The team alone cannot keep Six Sigma efforts from fading away; the ability to build solid support for the continuous improvement is the key elements of sustained improvement.

Although the development of Six Sigma implementation and integration framework in the context of Malaysia IT industry is conceptualized based on three case companies covering the three main IT business areas; the roadmap framework was considered useful, representative and usable in providing guidance and assistance to potential and new comers aiming to explore Six Sigma as a means of continuous improvement. Despite the general overview of Six Sigma roadmap to QIM implementation, the roadmap also demonstrated other secondary external factors which may influence the success rate of QIM implementation in the context of IT project management.

Lastly, the organizational culture with the characteristics of participative, flexible, resistant and risk-taking was significantly related to QIM implementation. What really matters is whether or not an IT company has a culture that supports quality improvement work and an approach that encourages flexible implementation by allowing more than one QIM (or sometime several QIMs) to be implemented and integrated with quality control approach where aspects of evaluation criteria are achieved and promising on-going revolutionary results are met.

Despite the shortcoming of the challenges faced by the framework which was only validated and evaluated by three case companies, the research outcomes from the exploratory case study yield significant contributions to the Malaysian IT industry providing a broader and comprehensive views of how Six Sigma took the stage as a possible trend to be adopted and integrated in the near future. The validity of the framework is not only limited to exploratory case studies; it encompasses vast development outcomes from a set of comprehensive literature reviews along with collected opinions from IT experts and specialists in the Malaysian IT industry. Therefore, the framework provide a general overview and fundamental kick-start guidance to IT companies seeking and exploring the potential of Six Sigma as a means of continuous improvement; as well as the way Six Sigma can be expanded and extended to include new essentials that are critical to successful QIM implementation.

9.5 Future Research Direction

Despite the limitations of this research, the developed roadmap of QIM selection and framework for Six Sigma implementation and integration provides opportunities for future research. The directions for future research are outlined in the following:

- **Expanding the 'roadmap to QIM selection' to include additional QIMs, and exploring other important factor for the considerations in QIM selection process**

The next research target is to construct a more comprehensive roadmap to include all possible QIMs adopted and implemented in the field of IT industry. The roadmap should expand to explore the sections of respective QIM's structure (i.e. resources, infrastructure, staff, credentials, policies, standards etc.), process (i.e. assessment, safety, continuity, costing, management etc.), approach (i.e. quality assurance, quality control or both) and measurable performance variables (i.e. satisfaction, value, cost effectiveness, function etc.). In summary, the roadmap should provide a broader view of its' purpose, tools and techniques used, cultural issues, implementation durations, support credentials as well as the examples of success stories of organizations. This high level informative knowledge could be served as critical decisions criteria regarding the amount of effort, knowledge, time, personnel and commitment required to adopt any QIM in the IT industry.

- **Validate and evaluate the framework with more samples of IT case companies in the area of IT Product, IT Service and IT Process**

Every IT project is designed to produce a unique product, service or result undertaken to meet unique goals and objectives. Due to this reason, improvement outcome(s) of the IT company resulting from the Six Sigma implementation and integration is also unique. These collective unique outcomes from IT company of various backgrounds could help to further fine-tune the framework by incorporating more well-rounded informative details to aid the decision making process. The framework can be improved to provide a more general view of Six Sigma implementation and integration not only limited to the Malaysian IT industry context only but to the entire IT industry in the world. The more the framework used to evaluate and validate cases in the IT industry, the higher the confident where the framework could be proven and adopted as part of the decision criteria whenever Six Sigma is the choice of QIM.

- **Expand the PMMM assessment to include project performance assessment not limiting to project management excellence assessment only**

The assessment of PMM level has somehow expanded the author's interest to explore the relationship between PMMM level, project management excellence and project performance in the context of QIM implementation; the implications as well as a step-by-step guidance leading to matured processes. This is vital to increase the success rate of QIM implementation by addressing the misconceptions and mistakes leading to quality system failure. The aim is to maximize IT business advantages by enhancing product quality and improving process routine to optimize performance earnings and performance quality.

- **Expand the analysis of critical success factors, critical failure factors, resistance factor etc. into QIM's hierarchy of needs for successful QIM implementation in Malaysia's IT industry**

The author sees the potential of summarizing the critical success factors, critical failure factors, resistance factors, relevant survey findings, project management knowledge etc. into a pyramid hierarchy of needs for successful QIM implementation in the Malaysia's IT industry. The suggestion of interpreting QIM's hierarchy of needs represented as a pyramid with the more basic needs of "project management knowledge" at the bottom; as one go upward climb, the needs for successful QIM's implementation will be more complex. The next level of needs is "sanctioned team direction", followed by "accountability", "human factor" and "culture".

Indeed, the QIM's hierarchy of needs for successful QIM implementation is concerned with the basic fundamental resources and *project management knowledge* of a project team prior to adopting any QIM. The next step is to include both top management and operational management team *sharing same project goals and direction*. Every team members (i.e. project manager, project leader and team member) are *accountable and responsible* for project deliverables, project health and project performance. Despite the procedural processes are in place, the success and failure of the project is greatly dependent on *human factors* where positive or negative *culture* is formed and practiced crossed the project team. It is the nature of culture (i.e. healthy or unhealthy) that guides individual decisions and actions at the unconscious level. As a result, it can have a potent effect on a company's QIM performance.

However, the research idea of QIM's hierarchy of needs for successful QIM implementation is only at the initial pre-conceptualize phase and extensive efforts on literature reviews is required to support this idea.

9.6 Conclusion

The future of the IT world is full of challenges. Many qualitative and quantitative researches related to the implementation of multiple process improvement frameworks (either is existent or virtually non-existent) are creating daunting challenges for IT project management in many aspects. Not only there is a growth in the use of individual quality improvement initiatives and standards but many organizations also implement several QIM frameworks simultaneously. Due to time factor evolution in the Malaysia IT industry, it is quite common for a long established IT company to practice, apply and adopt more than one QIM; formally or informally in day-to-day project activities in search of project performance excellence. Despite the possibility of implementing a new QIM, the awareness of integrating a third party quality improvement initiative is one of the most efficient and effective ways of bringing the project quality performance to higher level without "throwing away" the established procedures and policies from existing QIM.

Malaysian IT companies have strongly voiced their dissatisfaction and difficulties in matching their current QIM practice performances against long term company directions. IT companies are interested in improving their products, services and processes by implementing or integrating QIM which demonstrate a total solution in the aspect of operational and procedural methods to address customers' feedback. IT companies seek a flexible QIM which is capable of "patching up" the grey area(s) from an existing QIM. In view of the fact that most QIMs practiced in the Malaysia IT industry are skewed towards quality assurance, the decision for a quality control in QIM implementation and integration is highly recommended for long term survival. This is because the competitive and stressed environment leaves little room for errors in data quality and customer satisfaction. One must deliver and develop products and services at the ideal target (or acceptable level) demanded by the customers.

By developing a systematic framework, this research aims to bridge the visible gap in the QIM adoption in Malaysian IT companies by providing new insight to broaden the implementation and integration of Six Sigma beyond manufacturing community into any IT business areas to scale business efforts, to tackle businesses and operational problems and to achieve breakthrough in renewing the entire business. Furthermore, this study also contributes to address the "potential" of other external factors which may directly or indirectly affect the success rate of QIM implementation or integration; and its continuity as a means of continuous improvement. These criteria are indeed necessary and vital for market opportunities as quality improvement is a long term endeavour which takes much effort and resources to realize the benefits in the long run.

This chapter concluded the research findings of current study and successfully mapped to research objectives and questions, discussed its major contributions and implications to QIM selection, adoption and integration, highlighted limitations of the research and proposed future research directions. It is hoped that this study has made significant contributions to the understanding of Six Sigma adoption and integration in the Malaysian IT industry in both theory and practice.

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Appendices

Appendix-1 Questionnaire: Quality Improvement Methodologies in Malaysia

Good morning/afternoon/evening. We are academic researchers from the University of Nottingham (Malaysia Campus). We are currently conducting a study on quality improvement methodologies for the IT related business area. Your input is valuable to our research findings and your effort is greatly appreciated. We hope you could spare us 15-20 minutes for this questionnaire. Thank you.

We are a group of students from The University of Nottingham (Malaysia Campus). As part of our research project, we are currently undertaking a research project to determine different types of quality improvement methodologies implemented in the field of IT in Malaysia. At the same time, we would like to measure the quality improvement awareness from different level of line-management in the area of concept, objective, advantages, disadvantages, critical success factor, criticisms etc.

We kindly request your help in completing the following short questionnaire regarding your organization. Your help is greatly appreciated and your prompt response and timely completion of the survey will be one of the keys contribute to this survey success. We would be much happy to share the results if you need.

You may choose NOT to enter your details on the questionnaire to remain anonymous. This questionnaire should take no longer than 10 minutes of your time. Your response is of the utmost importance to us.

There are 45 questions in this survey

Respondent's Details

1 Please write your answer(s) here:

Name : {NOTEMPTY}	
Company's Address : {NOTEMPTY}	
Company's Fax : {NOTEMPTY}	
Company's Name : {NOTEMPTY}	
Company's Tel : {NOTEMPTY}	

SECTION A - COMPANY BACKGROUND

2 The organization business nature: *
Please choose only one of the following:

IT Software House
Consulting Services
Hardware Retailer
Hardware Manufacturer
Software Distributor
Other

3 The number of employees in the organization: *
Please choose only one of the following:

< 5
5 - 19
20 - 50
Other

4 The number of years the company has been in business: *
Please choose only one of the following:

< 1 year
1 - 3 years
3 - 4 years
4 - 6 years
6 - 8 years
Other

SECTION B - RESPONDENT'S BACKGROUND

5 Your Role / Designation in the organization: *
Please choose only one of the following:

Business Owner
Project Manager
Quality Manager
Consultant
System Analyst
Software Engineer / Developer
System Administrator
Business Analyst
Other

6 Working experience:

	Years
Total Working Experience:	
Working Experience for Current Position:	

SECTION C - QUALITY IMPROVEMENT METHODOLOGY

7 Which is/are the quality improvement methodology(ies) adopted for quality assurance as a means of continuous improvement for your business?
Check any that apply:

QIM	**Past**	**Current**	**Future**
Capability Maturity Model (CMM-I or CMM)	☐	☐	☐
ISO9000	☐	☐	☐
Business Process Reengineering	☐	☐	☐
SPICE (Software Process Improvement and Capability Determination)	☐	☐	☐
Balance Scorecard	☐	☐	☐
BOOTSTRAP	☐	☐	☐

Information Technology Infrastructure Library (ITIL)	☐	☐	☐
PSP (Personal Software Process)	☐	☐	☐
Lean-Sigma	☐	☐	☐
Six Sigma	☐	☐	☐

8 Which level of CMM-I or CMM does the company currently implementing?
[Only answer this question if you answered to question 'Q5a]
Please choose the appropriate response for each item:

	Level-1	Level-2	Level-3	Level-4	Level-5
Level of CMM or CMM-I	○	○	○	○	○

9 What is your satisfaction level with the performance of your current quality improvement methodology? *
Please choose the appropriate response for each item:

	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied
Level of Satisfaction	○	○	○	○

10 What are your company's main reasons for adopting a quality improvement methodology?
Please choose the appropriate response for each item:

Factors	1	2	3	4	5
Market Pressure	○	○	○	○	○
Vendor's Requirement	○	○	○	○	○
Symbolization of Quality	○	○	○	○	○
Customer's Expectation	○	○	○	○	○
Trend	○	○	○	○	○
Corporate Sustainability	○	○	○	○	○
Getting things right	○	○	○	○	○
Discipline enforcement	○	○	○	○	○
Competition with competitors	○	○	○	○	○
Require constant tracking	○	○	○	○	○

Please rate your answer in accordance to weight: 5-most important; 1-least important.

11 Do you have a quality assurance department or personnel(s) managing and handling day-to-day quality operations? *
Please choose only one of the following:

○ No
○ Other

FTE = Full time employees.
If Yes, please indicate the number of FTEs handling QA activities.

12 In your opinion, are quality improvement methodologies really necessary for organisations? *
Please choose only one of the following:

○ No
○ Other

13 How is quality measured in your organization?
Please choose all that apply:

☐ Acceptibility – Aesthetics, usability, functionality, etc.
☐ Compliance – Ability to meet product specifications
☐ Customer Satisfaction – Results of customer feedback
☐ Defect Counts – Warranty, maintenance, recall, repair
☐ Reliability – The measure of uptime versus downtime
☐ Responsiveness – Ability to respond to requests quickly
☐ Timeliness – Ability to deliver on time
☐ Variation – Difference between planned and actual schedules
Other:

14 Which of the following personnel have authority in the decision making process for all IT projects pertaining to quality assurance matters? *
[Only answer this question if you answered to question 'Q7]
Please choose all that apply:

☐ Project Manager / Project Leader
☐ Project/Product Champion
☐ QA Manager
☐ Department Manager / Director

☐Management Team
☐Project Sponsor
Other:

You may select more than one answer.

15 Most of the Performance Appraisal (PA) system is designed to encourage the commitment of middle management to the success of quality assurance implementation. Does your company align the quality assurance benefits as part of the KPI in the annual Performance Appraisal system?*
[Only answer this question if you answered to question 'Q7]
Please choose only one of the following:

○No
○Other

16 How much is the contribution (in %) of quality assurance towards individual KPI?
[Only answer this question if you answered to question 'Q7]
Please write a multiple of 5 between 5 and 50 for each item:

	Contribution of KPIs (in %)
Non-Executive	
Operation Executive	
Executive	
Senior Executive	
Manager	
Senior Manager	
Director	

17 In general, how much project time is allocated for quality improvement activities as a means of continuous improvement in handling, managing and controlling the quality of the project output?*
[Only answer this question if you answered to question 'Q7 *and* if you answered 'Yes' to question '12a]
Please choose only one of the following:

○10%
○20%
○30%
○40%
○Other

18 What is the minimum amount of training provided to the project team members before being assigned to formal quality assurance projects? *
[Only answer this question if you answered to question 'Q7]
Please choose only one of the following:

○Half (0.5) day
○One (1.0) day
○Two (2.0) days
○Three (3.0) days
○Four (4.0) days
○Other

19 What are the measurement metric(s) for non-conformance, inconsistency, variation, fault, bug,complaint, dissatisfaction etc for the adopted quality improvement methodology?

Examples of Measurement Metric
E.g (i) Generate Monthly Sales report (by customer | by product category) by last week of every month
E.g (ii) Generate Monthly Employees Salary report (by department) by first week of every month
E.g (iii) Time Taken for month-end sales account closing is 2 days per department

Please write your answer(s) here:

R1
R2
R3

20 After the implementation of the adopted quality improvement methodology, what are the Primary measurable benefits gained from this continuous initiative?
Please choose all that apply and provide a comment:

☐Increase customer satisfaction by (%)

☐ Reduce customer complaints by (%)
☐ Reduce software bugs by (%)
☐ Reduce transaction error by (%)
☐ Save project budget by (%)
☐ Increase market share by (%)
☐ Increase efficiency and effectiveness of decision making by (%)
☐ Time saving in data merging by (%)
☐ Reduce cycle time by (%)
☐ Saving of RM
☐ Others, please specify (1)
☐ Others,please specify (2)
☐ Others, please specify (3)
☐ Others, please specify (4)

You may select more than one.

21 After the implementation of the adopted quality improvement methodology, what are the Secondary measurable benefits gained from this continuous initiative?

Please choose all that apply:

☐ Improve company's reputation
☐ Improve employee's morale
☐ Improve employee's motivation
☐ Improve cross functional team work
☐ Improve efficiency and effectiveness
☐ Improve project management process
☐ Ability to retain customers
☐ Ability to foster customer loyalty
Other:

You may select more than one

22 In the IT business area of Process / Service / Product, indicate which are the adopted tools/techniques and rate them accordingly.

Please choose the appropriate response for each item: Please rate (0-never used) and (4-most commonly used).

	0- never	1- rarely	2- sometimes	3- often	4- very often
DFD (Data flow diagram)	○	○	○	○	○
Gap analysis	○	○	○	○	○
Process mapping	○	○	○	○	○
Voice of customer analysis	○	○	○	○	○
Cost-of-poor-quality (COPQ)	○	○	○	○	○
Statistical process control (SPC)	○	○	○	○	○
Design for experiments (DoE)	○	○	○	○	○
Taguchi methods	○	○	○	○	○
Process capability analysis (PCA)	○	○	○	○	○
Cause and Effect Diagram	○	○	○	○	○
Cost Benefit Analysis	○	○	○	○	○
Correlation Analysis	○	○	○	○	○
Regression Analysis	○	○	○	○	○
Two Sample T-Test	○	○	○	○	○
ANOVA	○	○	○	○	○
Earned Value Analysis (EVA)	○	○	○	○	○
Gap Analysis	○	○	○	○	○
History / Pareto Chart / Run Chart / Line Chart	○	○	○	○	○
Kano Analysis	○	○	○	○	○
Process Map	○	○	○	○	○
Affinity Diagram	○	○	○	○	○
SIPOC Diagram	○	○	○	○	○
Spider Charts	○	○	○	○	○
Flowcharts	○	○	○	○	○

23 Please specify and rank any other tools/techniques that we may may not have included.

Please write your answer(s) here:

Other tools/techniques (1):

Other tools/techniques (2):
Other tools/techniques (3):

24 Some resistance factors may have been encountered during the implementation of your quality management initiative. We have grouped the resistance factors to several grouping.
For each factor, please rate the level of significance according to the scale provided.

ORGANIZATIONAL FACTORS: HUMAN FACTORS *
Please choose the appropriate response for each item:

	Not a Factor	May be a factor	significant factor	VERY significant factor
Insufficient training and awareness in ALL levels of the organization				
Lack of understanding of concepts involved				
Lack of teamwork and participation of ALL levels in the organization				
Lack of leadership and professional knowledge				
Lack of support from senior management				
Too Much bureaucracy				
Lack of satisfaction during implementation				
Reduction of morale due to long time lapse before visible results				
Reduction of morale due to lack of updates on effort and lack of celebration of small successes				
Lack of Motivation via lectures and workshops				
Forfeit when hurdles encountered during implementation				

25 ORGANIZATIONAL FACTORS: POLITICAL FACTORS
Please choose the appropriate response for each item:

	Not a Factor	May be a factor	significant factor	VERY significant factor
Lack of clear organizational and/or quality policies making intentions clear regarding the quality improvement initiative				

This is an optional question.

26 ORGANIZATIONAL FACTORS: GOALS *
Please choose the appropriate response for each item:

	Not a Factor	May be a factor	significant factor	VERY significant factor
Lack of clear goals and objectives				
Failure to conduct an initial analysis before implementation				
Initiative not suited to organization's best interests				
Initiative not aligned to organization's needs; following initiative 'by-the-book'				
Implementation is counterproductive; causes distraction from more urgent needs				
Unrealistic expectations towards result on a time or quality based scale				
Neglecting to include adaptation period in plan				

27 ORGANIZATIONAL FACTORS: CULTURAL CHANGES *
Please choose the appropriate response for each item:

	Not a Factor	May be a factor	significant factor	VERY significant factor
Fear of change and job insecurity				
Lack of a tactical approach to implementing cultural changes				

28 ORGANIZATIONAL FACTORS: CHANGE MANAGEMENT *
Please choose the appropriate response for each item:

	Not a Factor	May be a factor	significant factor	VERY significant factor
Insufficient analysis of current situation of software process				
Simultaneous focus on improvement in several areas				

29 PROJECT FACTORS: BUDGETS AND ESTIMATES *
Please choose the appropriate response for each item:

	Not a Factor	May be a factor	significant factor	VERY significant factor
Costs higher than budgeted	○	○	○	○
Lack of short term returns	○	○	○	○
Lack of understanding that focus is placed on long term returns instead of short term ones	○	○	○	○
Expecting instant results; unrealistic expectations	○	○	○	○

30 PROJECT FACTORS: DOCUMENTATION *
Please choose the appropriate response for each item:

	Not a Factor	May be a factor	significant factor	VERY significant factor
Excessive documentation and formality	○	○	○	○
Lack of proper documentation management system	○	○	○	○
Increased workload and required discipline	○	○	○	○

31 Please specify and rank any other resistance factors that we may have missed out.
Please write your answer here:

SECTION D - QUALITY IMPROVEMENT MEHTODOLOGIES AWARENESS

32 Is Six Sigma used in your organisation? *
Please choose only one of the following:

○Yes
○No

33 What is your impression towards Six Sigma? *
Please choose all that apply:

☐An opportunity
☐A cost
☐A passing fad
☐A possible trend to adopt
Other:

You may select more than one answer.

34 If Six Sigma were to be implemented in your organization, what are the resistance factors would you expect to encounter? *
[Only answer this question if you answered 'No' to question 'Q19]
Please choose the appropriate response for each item:

	High	Medium	Low
People related issues	○	○	○
Poor Leadership	○	○	○
Time Consumption	○	○	○
Lack technical capacity/training	○	○	○
Lack of organizational buy-in	○	○	○
Resistance to change	○	○	○
High budget cost	○	○	○
Organizational culture and environment	○	○	○
Operational overkill (over analysis)	○	○	○
Intangible returns	○	○	○
Inappropriate application	○	○	○

For EACH resistance factor, please indicate the level of impact.

35 Please specify any other resistance factors that we may have missed out.
[Only answer this question if you answered 'No' to question 'Q19]
Please write your answer here:

This is an optional question.

36 What are the benefits do you expect to reap if Six Sigma were to be implemented in your organization? *
[Only answer this question if you answered 'No' to question 'Q19]
Please choose the appropriate response for each item:

	Strongly Agree	Agree	Disagree	Strongly Disagree
Increased effectiveness				
Better sustainability				
Reduces costs				
Significant improvement of quality				
Processes optimized				
Better delivery				
Better job satisfaction				
Improved organizational culture and environment				
Increased company reputation				
Increased customer satisfaction				

For EACH of the benefit, please indicate your level of agreement.

37 Please specify any other expected benefits that we may have missed out.
[Only answer this question if you answered 'No' to question 'Q19]
Please write your answer here:

This is an optional question.

38 Do you think it is possible to implement Six Sigma into the field of Information Technology (IT)? *
[Only answer this question if you answered 'No' to question 'Q19]
Please choose only one of the following:

- Yes
- No

39 What are the different types of certification(s) do your Six Sigma practitioners have in your organisation? *
[Only answer this question if you answered 'Yes' to question 'Q19]
Please choose all that apply:

- Six Sigma White Belt
- Six Sigma Yellow Belt
- Six Sigma Green Belt
- Six Sigma Black Belt
- Six Sigma Master Black Belt

You may choose more than one answer.

40 How many of the employees in your company have : *
[Only answer this question if you answered 'Yes' to question 'Q19]
Please write a number between 0 and 20 for each item:

	No of Employees
Received Six Sigma training	
Obtained Six Sigma certification	

41 Kindly indicate if you agree or disagree with the following statements. *
[Only answer this question if you answered 'Yes' to question 'Q19]
Please choose the appropriate response for each item:

	Strongly Agree	Agree	Disagree	Strongly Disagree
Increased effectiveness				
Better sustainability				
Reduces costs				
Significant improvement of quality				
Processes optimized				
Better delivery				
Better job satisfaction				
Improved organizational culture and environment				
Increased company reputation				
Increased customer satisfaction				

For EACH statement, please indicate your level of agreement.

42 Please specify any other expected benefits that we may have missed out.

[Only answer this question if you answered 'Yes' to question 'Q19]
Please write your answer here:

This is an optional question.

43 What are the resistance factors you encountered during Six Sigma implementation? *
[Only answer this question if you answered 'Yes' to question 'Q19]
Please choose the appropriate response for each item:

	High	Medium	Low
People related issues	○	○	○
Poor Leadership	○	○	○
Time Consumption	○	○	○
Lack technical capacity/training	○	○	○
Lack of organizational buy-in	○	○	○
Resistance to change	○	○	○
High budget cost	○	○	○
Organizational culture and environment	○	○	○
Operational overkill (over analysis)	○	○	○
Intangible returns	○	○	○
Inappropriate application	○	○	○

For EACH resistance factor, please indicate the level of impact.

44 Please specify any other resistance factors that we may have missed out.
[Only answer this question if you answered 'Yes' to question 'Q19]
Please write your answer here:

This is an optional question.

45 Which Six Sigma approach do you adopt in your company? *
[Only answer this question if you answered 'Yes' to question 'Q19]
Please choose all that apply:

☐ DMAIC (Design, Measure, Analyze, Improve, Control)
☐ DCCDI (Define, Customer, Concept, Design, Implement)
☐ DMADV (Define, Measure, Analyze, Design, Verify)
☐ IDOV (Identify, Design, Optimize, Validate)
☐ ICOV (Identify, Conceptualize, Optimize, Verify)
Other:

You may select more than one answer.

Appendix-2 Interview Question

Company Background

- How is the business nature of the company?
- What are the major business areas the company currently involves?
- Who are the customers?
- What are the sizes of business related resources (i.e. staff, software, hardware etc.)

Business-related Activities and Operations

- What are the various business activities and procedural operations for respective business areas?
- How is the work flow (in detail) of different business activities / operations?
- What are the issues or problems faced with existing business-related activities?
- Is there anything in particular been planned to overcome the issues or problems?
- How is the performance of projects in the past? Current?
- What are the activities involve from project initiation to project closure?
- How is the structure of the project team?

Pattern of Quality Improvement Methodology (QIM)

- Does the company adopt any form of QIM?
- If so, is the QIM adopted formally or informally?
- How long has this QIM been adopted?
- Does the QIM been uniformly adopted to all business activities or selected activities?
- Is there any measurement metric(s) for the adopted QIM? If so, what is/are the measurement metric(s)?

Appendix-3 SLA Expiry Calculation Chart

Day	Time-In	Expiry By …		Time-In	Expiry By …		Time-In	Expiry By …		Time-In	Expiry By …	
Monday .. Thursday	9:00 AM	Same Day	1:00 PM	10:00 AM	Same Day	2:00 PM	11:00 AM	Same Day	3:00 PM	12:00 PM	Same Day	4:00 PM
Monday .. Thursday	9:01 AM	Same Day	1:01 PM	10:01 AM	Same Day	2:01 PM	11:01 AM	Same Day	3:01 PM	12:01 PM	Same Day	4:01 PM
Monday .. Thursday	9:02 AM	Same Day	1:02 PM	10:02 AM	Same Day	2:02 PM	11:02 AM	Same Day	3:02 PM	12:02 PM	Same Day	4:02 PM
Monday .. Thursday	9:03 AM	Same Day	1:03 PM	10:03 AM	Same Day	2:03 PM	11:03 AM	Same Day	3:03 PM	12:03 PM	Same Day	4:03 PM
Monday .. Thursday	9:04 AM	Same Day	1:04 PM	10:04 AM	Same Day	2:04 PM	11:04 AM	Same Day	3:04 PM	12:04 PM	Same Day	4:04 PM
Monday .. Thursday	9:05 AM	Same Day	1:05 PM	10:05 AM	Same Day	2:05 PM	11:05 AM	Same Day	3:05 PM	12:05 PM	Same Day	4:05 PM
Monday .. Thursday	9:06 AM	Same Day	1:06 PM	10:06 AM	Same Day	2:06 PM	11:06 AM	Same Day	3:06 PM	12:06 PM	Same Day	4:06 PM
Monday .. Thursday	9:07 AM	Same Day	1:07 PM	10:07 AM	Same Day	2:07 PM	11:07 AM	Same Day	3:07 PM	12:07 PM	Same Day	4:07 PM
Monday .. Thursday	9:08 AM	Same Day	1:08 PM	10:08 AM	Same Day	2:08 PM	11:08 AM	Same Day	3:08 PM	12:08 PM	Same Day	4:08 PM
Monday .. Thursday	9:09 AM	Same Day	1:09 PM	10:09 AM	Same Day	2:09 PM	11:09 AM	Same Day	3:09 PM	12:09 PM	Same Day	4:09 PM
Monday .. Thursday	9:10 AM	Same Day	1:10 PM	10:10 AM	Same Day	2:10 PM	11:10 AM	Same Day	3:10 PM	12:10 PM	Same Day	4:10 PM
Monday .. Thursday	9:11 AM	Same Day	1:11 PM	10:11 AM	Same Day	2:11 PM	11:11 AM	Same Day	3:11 PM	12:11 PM	Same Day	4:11 PM
Monday .. Thursday	9:12 AM	Same Day	1:12 PM	10:12 AM	Same Day	2:12 PM	11:12 AM	Same Day	3:12 PM	12:12 PM	Same Day	4:12 PM
Monday .. Thursday	9:13 AM	Same Day	1:13 PM	10:13 AM	Same Day	2:13 PM	11:13 AM	Same Day	3:13 PM	12:13 PM	Same Day	4:13 PM
Monday .. Thursday	9:14 AM	Same Day	1:14 PM	10:14 AM	Same Day	2:14 PM	11:14 AM	Same Day	3:14 PM	12:14 PM	Same Day	4:14 PM
Monday .. Thursday	9:15 AM	Same Day	1:15 PM	10:15 AM	Same Day	2:15 PM	11:15 AM	Same Day	3:15 PM	12:15 PM	Same Day	4:15 PM
Monday .. Thursday	9:16 AM	Same Day	1:16 PM	10:16 AM	Same Day	2:16 PM	11:16 AM	Same Day	3:16 PM	12:16 PM	Same Day	4:16 PM
Monday .. Thursday	9:17 AM	Same Day	1:17 PM	10:17 AM	Same Day	2:17 PM	11:17 AM	Same Day	3:17 PM	12:17 PM	Same Day	4:17 PM
Monday .. Thursday	9:18 AM	Same Day	1:18 PM	10:18 AM	Same Day	2:18 PM	11:18 AM	Same Day	3:18 PM	12:18 PM	Same Day	4:18 PM
Monday .. Thursday	9:19 AM	Same Day	1:19 PM	10:19 AM	Same Day	2:19 PM	11:19 AM	Same Day	3:19 PM	12:19 PM	Same Day	4:19 PM
Monday .. Thursday	9:20 AM	Same Day	1:20 PM	10:20 AM	Same Day	2:20 PM	11:20 AM	Same Day	3:20 PM	12:20 PM	Same Day	4:20 PM
Monday .. Thursday	9:21 AM	Same Day	1:21 PM	10:21 AM	Same Day	2:21 PM	11:21 AM	Same Day	3:21 PM	12:21 PM	Same Day	4:21 PM
Monday .. Thursday	9:22 AM	Same Day	1:22 PM	10:22 AM	Same Day	2:22 PM	11:22 AM	Same Day	3:22 PM	12:22 PM	Same Day	4:22 PM
Monday .. Thursday	9:23 AM	Same Day	1:23 PM	10:23 AM	Same Day	2:23 PM	11:23 AM	Same Day	3:23 PM	12:23 PM	Same Day	4:23 PM
Monday .. Thursday	9:24 AM	Same Day	1:24 PM	10:24 AM	Same Day	2:24 PM	11:24 AM	Same Day	3:24 PM	12:24 PM	Same Day	4:24 PM
Monday .. Thursday	9:25 AM	Same Day	1:25 PM	10:25 AM	Same Day	2:25 PM	11:25 AM	Same Day	3:25 PM	12:25 PM	Same Day	4:25 PM
Monday .. Thursday	9:26 AM	Same Day	1:26 PM	10:26 AM	Same Day	2:26 PM	11:26 AM	Same Day	3:26 PM	12:26 PM	Same Day	4:26 PM
Monday .. Thursday	9:27 AM	Same Day	1:27 PM	10:27 AM	Same Day	2:27 PM	11:27 AM	Same Day	3:27 PM	12:27 PM	Same Day	4:27 PM
Monday .. Thursday	9:28 AM	Same Day	1:28 PM	10:28 AM	Same Day	2:28 PM	11:28 AM	Same Day	3:28 PM	12:28 PM	Same Day	4:28 PM
Monday .. Thursday	9:29 AM	Same Day	1:29 PM	10:29 AM	Same Day	2:29 PM	11:29 AM	Same Day	3:29 PM	12:29 PM	Same Day	4:29 PM
Monday .. Thursday	9:30 AM	Same Day	1:30 PM	10:30 AM	Same Day	2:30 PM	11:30 AM	Same Day	3:30 PM	12:30 PM	Same Day	4:30 PM
Monday .. Thursday	9:31 AM	Same Day	1:31 PM	10:31 AM	Same Day	2:31 PM	11:31 AM	Same Day	3:31 PM	12:31 PM	Same Day	4:31 PM
Monday .. Thursday	9:32 AM	Same Day	1:32 PM	10:32 AM	Same Day	2:32 PM	11:32 AM	Same Day	3:32 PM	12:32 PM	Same Day	4:32 PM
Monday .. Thursday	9:33 AM	Same Day	1:33 PM	10:33 AM	Same Day	2:33 PM	11:33 AM	Same Day	3:33 PM	12:33 PM	Same Day	4:33 PM
Monday .. Thursday	9:34 AM	Same Day	1:34 PM	10:34 AM	Same Day	2:34 PM	11:34 AM	Same Day	3:34 PM	12:34 PM	Same Day	4:34 PM
Monday .. Thursday	9:35 AM	Same Day	1:35 PM	10:35 AM	Same Day	2:35 PM	11:35 AM	Same Day	3:35 PM	12:35 PM	Same Day	4:35 PM
Monday .. Thursday	9:36 AM	Same Day	1:36 PM	10:36 AM	Same Day	2:36 PM	11:36 AM	Same Day	3:36 PM	12:36 PM	Same Day	4:36 PM
Monday .. Thursday	9:37 AM	Same Day	1:37 PM	10:37 AM	Same Day	2:37 PM	11:37 AM	Same Day	3:37 PM	12:37 PM	Same Day	4:37 PM
Monday .. Thursday	9:38 AM	Same Day	1:38 PM	10:38 AM	Same Day	2:38 PM	11:38 AM	Same Day	3:38 PM	12:38 PM	Same Day	4:38 PM
Monday .. Thursday	9:39 AM	Same Day	1:39 PM	10:39 AM	Same Day	2:39 PM	11:39 AM	Same Day	3:39 PM	12:39 PM	Same Day	4:39 PM
Monday .. Thursday	9:40 AM	Same Day	1:40 PM	10:40 AM	Same Day	2:40 PM	11:40 AM	Same Day	3:40 PM	12:40 PM	Same Day	4:40 PM
Monday .. Thursday	9:41 AM	Same Day	1:41 PM	10:41 AM	Same Day	2:41 PM	11:41 AM	Same Day	3:41 PM	12:41 PM	Same Day	4:41 PM
Monday .. Thursday	9:42 AM	Same Day	1:42 PM	10:42 AM	Same Day	2:42 PM	11:42 AM	Same Day	3:42 PM	12:42 PM	Same Day	4:42 PM
Monday .. Thursday	9:43 AM	Same Day	1:43 PM	10:43 AM	Same Day	2:43 PM	11:43 AM	Same Day	3:43 PM	12:43 PM	Same Day	4:43 PM
Monday .. Thursday	9:44 AM	Same Day	1:44 PM	10:44 AM	Same Day	2:44 PM	11:44 AM	Same Day	3:44 PM	12:44 PM	Same Day	4:44 PM
Monday .. Thursday	9:45 AM	Same Day	1:45 PM	10:45 AM	Same Day	2:45 PM	11:45 AM	Same Day	3:45 PM	12:45 PM	Same Day	4:45 PM
Monday .. Thursday	9:46 AM	Same Day	1:46 PM	10:46 AM	Same Day	2:46 PM	11:46 AM	Same Day	3:46 PM	12:46 PM	Same Day	4:46 PM
Monday .. Thursday	9:47 AM	Same Day	1:47 PM	10:47 AM	Same Day	2:47 PM	11:47 AM	Same Day	3:47 PM	12:47 PM	Same Day	4:47 PM
Monday .. Thursday	9:48 AM	Same Day	1:48 PM	10:48 AM	Same Day	2:48 PM	11:48 AM	Same Day	3:48 PM	12:48 PM	Same Day	4:48 PM
Monday .. Thursday	9:49 AM	Same Day	1:49 PM	10:49 AM	Same Day	2:49 PM	11:49 AM	Same Day	3:49 PM	12:49 PM	Same Day	4:49 PM
Monday .. Thursday	9:50 AM	Same Day	1:50 PM	10:50 AM	Same Day	2:50 PM	11:50 AM	Same Day	3:50 PM	12:50 PM	Same Day	4:50 PM
Monday .. Thursday	9:51 AM	Same Day	1:51 PM	10:51 AM	Same Day	2:51 PM	11:51 AM	Same Day	3:51 PM	12:51 PM	Same Day	4:51 PM
Monday .. Thursday	9:52 AM	Same Day	1:52 PM	10:52 AM	Same Day	2:52 PM	11:52 AM	Same Day	3:52 PM	12:52 PM	Same Day	4:52 PM
Monday .. Thursday	9:53 AM	Same Day	1:53 PM	10:53 AM	Same Day	2:53 PM	11:53 AM	Same Day	3:53 PM	12:53 PM	Same Day	4:53 PM
Monday .. Thursday	9:54 AM	Same Day	1:54 PM	10:54 AM	Same Day	2:54 PM	11:54 AM	Same Day	3:54 PM	12:54 PM	Same Day	4:54 PM
Monday .. Thursday	9:55 AM	Same Day	1:55 PM	10:55 AM	Same Day	2:55 PM	11:55 AM	Same Day	3:55 PM	12:55 PM	Same Day	4:55 PM
Monday .. Thursday	9:56 AM	Same Day	1:56 PM	10:56 AM	Same Day	2:56 PM	11:56 AM	Same Day	3:56 PM	12:56 PM	Same Day	4:56 PM
Monday .. Thursday	9:57 AM	Same Day	1:57 PM	10:57 AM	Same Day	2:57 PM	11:57 AM	Same Day	3:57 PM	12:57 PM	Same Day	4:57 PM
Monday .. Thursday	9:58 AM	Same Day	1:58 PM	10:58 AM	Same Day	2:58 PM	11:58 AM	Same Day	3:58 PM	12:58 PM	Same Day	4:58 PM
Monday .. Thursday	9:59 AM	Same Day	1:59 PM	10:59 AM	Same Day	2:59 PM	11:59 AM	Same Day	3:59 PM	12:59 PM	Same Day	4:59 PM
Monday .. Thursday	10:00 AM	Same Day	2:00 PM	11:00 AM	Same Day	3:00 PM	12:00 PM	Same Day	4:00 PM	**1:00 PM**	**Same Day**	**5:00 PM**

Day	Time-In	Expiry By ...		Time-In	Expiry By ...		Time-In	Expiry By ...		Time-In	Expiry By ...		Time-In	Expiry By ...	
Monday .. Thursday	1:00 PM	Same Day	5:00 PM	2:00 PM	NBD	10:00 AM	3:00 PM	NBD	11:00 AM	4:00 PM	NBD	12:00 PM	5:00 PM	NBD	1:00 PM
Monday .. Thursday	1:01 PM	NBD	9:01 AM	2:01 PM	NBD	10:01 AM	3:01 PM	NBD	11:01 AM	4:01 PM	NBD	12:01 PM	5:01 PM	NBD	1:00 PM
Monday .. Thursday	1:02 PM	NBD	9:02 AM	2:02 PM	NBD	10:02 AM	3:02 PM	NBD	11:02 AM	4:02 PM	NBD	12:02 PM	5:02 PM	NBD	1:00 PM
Monday .. Thursday	1:03 PM	NBD	9:03 AM	2:03 PM	NBD	10:03 AM	3:03 PM	NBD	11:03 AM	4:03 PM	NBD	12:03 PM	5:03 PM	NBD	1:00 PM
Monday .. Thursday	1:04 PM	NBD	9:04 AM	2:04 PM	NBD	10:04 AM	3:04 PM	NBD	11:04 AM	4:04 PM	NBD	12:04 PM	5:04 PM	NBD	1:00 PM
Monday .. Thursday	1:05 PM	NBD	9:05 AM	2:05 PM	NBD	10:05 AM	3:05 PM	NBD	11:05 AM	4:05 PM	NBD	12:05 PM	5:05 PM	NBD	1:00 PM
Monday .. Thursday	1:06 PM	NBD	9:06 AM	2:06 PM	NBD	10:06 AM	3:06 PM	NBD	11:06 AM	4:06 PM	NBD	12:06 PM	:	NBD	1:00 PM
Monday .. Thursday	1:07 PM	NBD	9:07 AM	2:07 PM	NBD	10:07 AM	3:07 PM	NBD	11:07 AM	4:07 PM	NBD	12:07 PM	:	NBD	1:00 PM
Monday .. Thursday	1:08 PM	NBD	9:08 AM	2:08 PM	NBD	10:08 AM	3:08 PM	NBD	11:08 AM	4:08 PM	NBD	12:08 PM	5:55 PM	NBD	1:00 PM
Monday .. Thursday	1:09 PM	NBD	9:09 AM	2:09 PM	NBD	10:09 AM	3:09 PM	NBD	11:09 AM	4:09 PM	NBD	12:09 PM	5:56 PM	NBD	1:00 PM
Monday .. Thursday	1:10 PM	NBD	9:10 AM	2:10 PM	NBD	10:10 AM	3:10 PM	NBD	11:10 AM	4:10 PM	NBD	12:10 PM	5:57 PM	NBD	1:00 PM
Monday .. Thursday	1:11 PM	NBD	9:11 AM	2:11 PM	NBD	10:11 AM	3:11 PM	NBD	11:11 AM	4:11 PM	NBD	12:11 PM	5:58 PM	NBD	1:00 PM
Monday .. Thursday	1:12 PM	NBD	9:12 AM	2:12 PM	NBD	10:12 AM	3:12 PM	NBD	11:12 AM	4:12 PM	NBD	12:12 PM	5:59 PM	NBD	1:00 PM
Monday .. Thursday	1:13 PM	NBD	9:13 AM	2:13 PM	NBD	10:13 AM	3:13 PM	NBD	11:13 AM	4:13 PM	NBD	12:13 PM	6:00 PM	NBD	1:00 PM
Monday .. Thursday	1:14 PM	NBD	9:14 AM	2:14 PM	NBD	10:14 AM	3:14 PM	NBD	11:14 AM	4:14 PM	NBD	12:14 PM	6:01 PM	NBD	1:00 PM
Monday .. Thursday	1:15 PM	NBD	9:15 AM	2:15 PM	NBD	10:15 AM	3:15 PM	NBD	11:15 AM	4:15 PM	NBD	12:15 PM	6:02 PM	NBD	1:00 PM
Monday .. Thursday	1:16 PM	NBD	9:16 AM	2:16 PM	NBD	10:16 AM	3:16 PM	NBD	11:16 AM	4:16 PM	NBD	12:16 PM	6:03 PM	NBD	1:00 PM
Monday .. Thursday	1:17 PM	NBD	9:17 AM	2:17 PM	NBD	10:17 AM	3:17 PM	NBD	11:17 AM	4:17 PM	NBD	12:17 PM	6:04 PM	NBD	1:00 PM
Monday .. Thursday	1:18 PM	NBD	9:18 AM	2:18 PM	NBD	10:18 AM	3:18 PM	NBD	11:18 AM	4:18 PM	NBD	12:18 PM	6:05 PM	NBD	1:00 PM
Monday .. Thursday	1:19 PM	NBD	9:19 AM	2:19 PM	NBD	10:19 AM	3:19 PM	NBD	11:19 AM	4:19 PM	NBD	12:19 PM	:	NBD	1:00 PM
Monday .. Thursday	1:20 PM	NBD	9:20 AM	2:20 PM	NBD	10:20 AM	3:20 PM	NBD	11:20 AM	4:20 PM	NBD	12:20 PM	:	NBD	1:00 PM
Monday .. Thursday	1:21 PM	NBD	9:21 AM	2:21 PM	NBD	10:21 AM	3:21 PM	NBD	11:21 AM	4:21 PM	NBD	12:21 PM	6:55 PM	NBD	1:00 PM
Monday .. Thursday	1:22 PM	NBD	9:22 AM	2:22 PM	NBD	10:22 AM	3:22 PM	NBD	11:22 AM	4:22 PM	NBD	12:22 PM	6:56 PM	NBD	1:00 PM
Monday .. Thursday	1:23 PM	NBD	9:23 AM	2:23 PM	NBD	10:23 AM	3:23 PM	NBD	11:23 AM	4:23 PM	NBD	12:23 PM	6:57 PM	NBD	1:00 PM
Monday .. Thursday	1:24 PM	NBD	9:24 AM	2:24 PM	NBD	10:24 AM	3:24 PM	NBD	11:24 AM	4:24 PM	NBD	12:24 PM	6:58 PM	NBD	1:00 PM
Monday .. Thursday	1:25 PM	NBD	9:25 AM	2:25 PM	NBD	10:25 AM	3:25 PM	NBD	11:25 AM	4:25 PM	NBD	12:25 PM	6:59 PM	NBD	1:00 PM
Monday .. Thursday	1:26 PM	NBD	9:26 AM	2:26 PM	NBD	10:26 AM	3:26 PM	NBD	11:26 AM	4:26 PM	NBD	12:26 PM	7:00 PM	NBD	1:00 PM
Monday .. Thursday	1:27 PM	NBD	9:27 AM	2:27 PM	NBD	10:27 AM	3:27 PM	NBD	11:27 AM	4:27 PM	NBD	12:27 PM	7:01 PM	NBD	1:00 PM
Monday .. Thursday	1:28 PM	NBD	9:28 AM	2:28 PM	NBD	10:28 AM	3:28 PM	NBD	11:28 AM	4:28 PM	NBD	12:28 PM	7:02 PM	NBD	1:00 PM
Monday .. Thursday	1:29 PM	NBD	9:29 AM	2:29 PM	NBD	10:29 AM	3:29 PM	NBD	11:29 AM	4:29 PM	NBD	12:29 PM	7:03 PM	NBD	1:00 PM
Monday .. Thursday	1:30 PM	NBD	9:30 AM	2:30 PM	NBD	10:30 AM	3:30 PM	NBD	11:30 AM	4:30 PM	NBD	12:30 PM	7:04 PM	NBD	1:00 PM
Monday .. Thursday	1:31 PM	NBD	9:31 AM	2:31 PM	NBD	10:31 AM	3:31 PM	NBD	11:31 AM	4:31 PM	NBD	12:31 PM	7:05 PM	NBD	1:00 PM
Monday .. Thursday	1:32 PM	NBD	9:32 AM	2:32 PM	NBD	10:32 AM	3:32 PM	NBD	11:32 AM	4:32 PM	NBD	12:32 PM	:	NBD	1:00 PM
Monday .. Thursday	1:33 PM	NBD	9:33 AM	2:33 PM	NBD	10:33 AM	3:33 PM	NBD	11:33 AM	4:33 PM	NBD	12:33 PM	:	NBD	1:00 PM
Monday .. Thursday	1:34 PM	NBD	9:34 AM	2:34 PM	NBD	10:34 AM	3:34 PM	NBD	11:34 AM	4:34 PM	NBD	12:34 PM	7:55 PM	NBD	1:00 PM
Monday .. Thursday	1:35 PM	NBD	9:35 AM	2:35 PM	NBD	10:35 AM	3:35 PM	NBD	11:35 AM	4:35 PM	NBD	12:35 PM	7:56 PM	NBD	1:00 PM
Monday .. Thursday	1:36 PM	NBD	9:36 AM	2:36 PM	NBD	10:36 AM	3:36 PM	NBD	11:36 AM	4:36 PM	NBD	12:36 PM	7:57 PM	NBD	1:00 PM
Monday .. Thursday	1:37 PM	NBD	9:37 AM	2:37 PM	NBD	10:37 AM	3:37 PM	NBD	11:37 AM	4:37 PM	NBD	12:37 PM	7:58 PM	NBD	1:00 PM
Monday .. Thursday	1:38 PM	NBD	9:38 AM	2:38 PM	NBD	10:38 AM	3:38 PM	NBD	11:38 AM	4:38 PM	NBD	12:38 PM	7:59 PM	NBD	1:00 PM
Monday .. Thursday	1:39 PM	NBD	9:39 AM	2:39 PM	NBD	10:39 AM	3:39 PM	NBD	11:39 AM	4:39 PM	NBD	12:39 PM	8:00 PM	NBD	1:00 PM
Monday .. Thursday	1:40 PM	NBD	9:40 AM	2:40 PM	NBD	10:40 AM	3:40 PM	NBD	11:40 AM	4:40 PM	NBD	12:40 PM	8:01 PM	NBD	1:00 PM
Monday .. Thursday	1:41 PM	NBD	9:41 AM	2:41 PM	NBD	10:41 AM	3:41 PM	NBD	11:41 AM	4:41 PM	NBD	12:41 PM	8:02 PM	NBD	1:00 PM
Monday .. Thursday	1:42 PM	NBD	9:42 AM	2:42 PM	NBD	10:42 AM	3:42 PM	NBD	11:42 AM	4:42 PM	NBD	12:42 PM	8:03 PM	NBD	1:00 PM
Monday .. Thursday	1:43 PM	NBD	9:43 AM	2:43 PM	NBD	10:43 AM	3:43 PM	NBD	11:43 AM	4:43 PM	NBD	12:43 PM	8:04 PM	NBD	1:00 PM
Monday .. Thursday	1:44 PM	NBD	9:44 AM	2:44 PM	NBD	10:44 AM	3:44 PM	NBD	11:44 AM	4:44 PM	NBD	12:44 PM	8:05 PM	NBD	1:00 PM
Monday .. Thursday	1:45 PM	NBD	9:45 AM	2:45 PM	NBD	10:45 AM	3:45 PM	NBD	11:45 AM	4:45 PM	NBD	12:45 PM	:	NBD	1:00 PM
Monday .. Thursday	1:46 PM	NBD	9:46 AM	2:46 PM	NBD	10:46 AM	3:46 PM	NBD	11:46 AM	4:46 PM	NBD	12:46 PM	:	NBD	1:00 PM
Monday .. Thursday	1:47 PM	NBD	9:47 AM	2:47 PM	NBD	10:47 AM	3:47 PM	NBD	11:47 AM	4:47 PM	NBD	12:47 PM	8:55 PM	NBD	1:00 PM
Monday .. Thursday	1:48 PM	NBD	9:48 AM	2:48 PM	NBD	10:48 AM	3:48 PM	NBD	11:48 AM	4:48 PM	NBD	12:48 PM	8:56 PM	NBD	1:00 PM
Monday .. Thursday	1:49 PM	NBD	9:49 AM	2:49 PM	NBD	10:49 AM	3:49 PM	NBD	11:49 AM	4:49 PM	NBD	12:49 PM	8:57 PM	NBD	1:00 PM
Monday .. Thursday	1:50 PM	NBD	9:50 AM	2:50 PM	NBD	10:50 AM	3:50 PM	NBD	11:50 AM	4:50 PM	NBD	12:50 PM	8:58 PM	NBD	1:00 PM
Monday .. Thursday	1:51 PM	NBD	9:51 AM	2:51 PM	NBD	10:51 AM	3:51 PM	NBD	11:51 AM	4:51 PM	NBD	12:51 PM	8:59 PM	NBD	1:00 PM
Monday .. Thursday	1:52 PM	NBD	9:52 AM	2:52 PM	NBD	10:52 AM	3:52 PM	NBD	11:52 AM	4:52 PM	NBD	12:52 PM	9:00 PM	NBD	1:00 PM
Monday .. Thursday	1:53 PM	NBD	9:53 AM	2:53 PM	NBD	10:53 AM	3:53 PM	NBD	11:53 AM	4:53 PM	NBD	12:53 PM	9:01 PM	NBD	1:00 PM
Monday .. Thursday	1:54 PM	NBD	9:54 AM	2:54 PM	NBD	10:54 AM	3:54 PM	NBD	11:54 AM	4:54 PM	NBD	12:54 PM	9:02 PM	NBD	1:00 PM
Monday .. Thursday	1:55 PM	NBD	9:55 AM	2:55 PM	NBD	10:55 AM	3:55 PM	NBD	11:55 AM	4:55 PM	NBD	12:55 PM	9:03 PM	NBD	1:00 PM
Monday .. Thursday	1:56 PM	NBD	9:56 AM	2:56 PM	NBD	10:56 AM	3:56 PM	NBD	11:56 AM	4:56 PM	NBD	12:56 PM	9:04 PM	NBD	1:00 PM
Monday .. Thursday	1:57 PM	NBD	9:57 AM	2:57 PM	NBD	10:57 AM	3:57 PM	NBD	11:57 AM	4:57 PM	NBD	12:57 PM	9:05 PM	NBD	1:00 PM
Monday .. Thursday	1:58 PM	NBD	9:58 AM	2:58 PM	NBD	10:58 AM	3:58 PM	NBD	11:58 AM	4:58 PM	NBD	12:58 PM	9:06 PM	NBD	1:00 PM
Monday .. Thursday	1:59 PM	NBD	9:59 AM	2:59 PM	NBD	10:59 AM	3:59 PM	NBD	11:59 AM	4:59 PM	NBD	12:59 PM	:	NBD	1:00 PM
Monday .. Thursday	2:00 PM	NBD	10:00 AM	3:00 PM	NBD	11:00 AM	4:00 PM	NBD	12:00 PM	5:00 PM	NBD	1:00 PM	:	NBD	1:00 PM

Day	Time-In	Expiry By ...		Time-In	Expiry By ...		Time-In	Expiry By ...		Time-In	Expiry By ...	
Friday	9:00 AM	Same Day	1:00 PM	10:00 AM	Same Day	2:00 PM	11:00 AM	Same Day	3:00 PM	12:00 PM	Same Day	4:00 PM
Friday	9:01 AM	Same Day	1:01 PM	10:01 AM	Same Day	2:01 PM	11:01 AM	Same Day	3:01 PM	12:01 PM	Same Day	4:01 PM
Friday	9:02 AM	Same Day	1:02 PM	10:02 AM	Same Day	2:02 PM	11:02 AM	Same Day	3:02 PM	12:02 PM	Same Day	4:02 PM
Friday	9:03 AM	Same Day	1:03 PM	10:03 AM	Same Day	2:03 PM	11:03 AM	Same Day	3:03 PM	12:03 PM	Same Day	4:03 PM
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Friday	9:07 AM	Same Day	1:07 PM	10:07 AM	Same Day	2:07 PM	11:07 AM	Same Day	3:07 PM	12:07 PM	Same Day	4:07 PM
Friday	9:08 AM	Same Day	1:08 PM	10:08 AM	Same Day	2:08 PM	11:08 AM	Same Day	3:08 PM	12:08 PM	Same Day	4:08 PM
Friday	9:09 AM	Same Day	1:09 PM	10:09 AM	Same Day	2:09 PM	11:09 AM	Same Day	3:09 PM	12:09 PM	Same Day	4:09 PM
Friday	9:10 AM	Same Day	1:10 PM	10:10 AM	Same Day	2:10 PM	11:10 AM	Same Day	3:10 PM	12:10 PM	Same Day	4:10 PM
Friday	9:11 AM	Same Day	1:11 PM	10:11 AM	Same Day	2:11 PM	11:11 AM	Same Day	3:11 PM	12:11 PM	Same Day	4:11 PM
Friday	9:12 AM	Same Day	1:12 PM	10:12 AM	Same Day	2:12 PM	11:12 AM	Same Day	3:12 PM	12:12 PM	Same Day	4:12 PM
Friday	9:13 AM	Same Day	1:13 PM	10:13 AM	Same Day	2:13 PM	11:13 AM	Same Day	3:13 PM	12:13 PM	Same Day	4:13 PM
Friday	9:14 AM	Same Day	1:14 PM	10:14 AM	Same Day	2:14 PM	11:14 AM	Same Day	3:14 PM	12:14 PM	Same Day	4:14 PM
Friday	9:15 AM	Same Day	1:15 PM	10:15 AM	Same Day	2:15 PM	11:15 AM	Same Day	3:15 PM	12:15 PM	Same Day	4:15 PM
Friday	9:16 AM	Same Day	1:16 PM	10:16 AM	Same Day	2:16 PM	11:16 AM	Same Day	3:16 PM	12:16 PM	Same Day	4:16 PM
Friday	9:17 AM	Same Day	1:17 PM	10:17 AM	Same Day	2:17 PM	11:17 AM	Same Day	3:17 PM	12:17 PM	Same Day	4:17 PM
Friday	9:18 AM	Same Day	1:18 PM	10:18 AM	Same Day	2:18 PM	11:18 AM	Same Day	3:18 PM	12:18 PM	Same Day	4:18 PM
Friday	9:19 AM	Same Day	1:19 PM	10:19 AM	Same Day	2:19 PM	11:19 AM	Same Day	3:19 PM	12:19 PM	Same Day	4:19 PM
Friday	9:20 AM	Same Day	1:20 PM	10:20 AM	Same Day	2:20 PM	11:20 AM	Same Day	3:20 PM	12:20 PM	Same Day	4:20 PM
Friday	9:21 AM	Same Day	1:21 PM	10:21 AM	Same Day	2:21 PM	11:21 AM	Same Day	3:21 PM	12:21 PM	Same Day	4:21 PM
Friday	9:22 AM	Same Day	1:22 PM	10:22 AM	Same Day	2:22 PM	11:22 AM	Same Day	3:22 PM	12:22 PM	Same Day	4:22 PM
Friday	9:23 AM	Same Day	1:23 PM	10:23 AM	Same Day	2:23 PM	11:23 AM	Same Day	3:23 PM	12:23 PM	Same Day	4:23 PM
Friday	9:24 AM	Same Day	1:24 PM	10:24 AM	Same Day	2:24 PM	11:24 AM	Same Day	3:24 PM	12:24 PM	Same Day	4:24 PM
Friday	9:25 AM	Same Day	1:25 PM	10:25 AM	Same Day	2:25 PM	11:25 AM	Same Day	3:25 PM	12:25 PM	Same Day	4:25 PM
Friday	9:26 AM	Same Day	1:26 PM	10:26 AM	Same Day	2:26 PM	11:26 AM	Same Day	3:26 PM	12:26 PM	Same Day	4:26 PM
Friday	9:27 AM	Same Day	1:27 PM	10:27 AM	Same Day	2:27 PM	11:27 AM	Same Day	3:27 PM	12:27 PM	Same Day	4:27 PM
Friday	9:28 AM	Same Day	1:28 PM	10:28 AM	Same Day	2:28 PM	11:28 AM	Same Day	3:28 PM	12:28 PM	Same Day	4:28 PM
Friday	9:29 AM	Same Day	1:29 PM	10:29 AM	Same Day	2:29 PM	11:29 AM	Same Day	3:29 PM	12:29 PM	Same Day	4:29 PM
Friday	9:30 AM	Same Day	1:30 PM	10:30 AM	Same Day	2:30 PM	11:30 AM	Same Day	3:30 PM	12:30 PM	Same Day	4:30 PM
Friday	9:31 AM	Same Day	1:31 PM	10:31 AM	Same Day	2:31 PM	11:31 AM	Same Day	3:31 PM	12:31 PM	Same Day	4:31 PM
Friday	9:32 AM	Same Day	1:32 PM	10:32 AM	Same Day	2:32 PM	11:32 AM	Same Day	3:32 PM	12:32 PM	Same Day	4:32 PM
Friday	9:33 AM	Same Day	1:33 PM	10:33 AM	Same Day	2:33 PM	11:33 AM	Same Day	3:33 PM	12:33 PM	Same Day	4:33 PM
Friday	9:34 AM	Same Day	1:34 PM	10:34 AM	Same Day	2:34 PM	11:34 AM	Same Day	3:34 PM	12:34 PM	Same Day	4:34 PM
Friday	9:35 AM	Same Day	1:35 PM	10:35 AM	Same Day	2:35 PM	11:35 AM	Same Day	3:35 PM	12:35 PM	Same Day	4:35 PM
Friday	9:36 AM	Same Day	1:36 PM	10:36 AM	Same Day	2:36 PM	11:36 AM	Same Day	3:36 PM	12:36 PM	Same Day	4:36 PM
Friday	9:37 AM	Same Day	1:37 PM	10:37 AM	Same Day	2:37 PM	11:37 AM	Same Day	3:37 PM	12:37 PM	Same Day	4:37 PM
Friday	9:38 AM	Same Day	1:38 PM	10:38 AM	Same Day	2:38 PM	11:38 AM	Same Day	3:38 PM	12:38 PM	Same Day	4:38 PM
Friday	9:39 AM	Same Day	1:39 PM	10:39 AM	Same Day	2:39 PM	11:39 AM	Same Day	3:39 PM	12:39 PM	Same Day	4:39 PM
Friday	9:40 AM	Same Day	1:40 PM	10:40 AM	Same Day	2:40 PM	11:40 AM	Same Day	3:40 PM	12:40 PM	Same Day	4:40 PM
Friday	9:41 AM	Same Day	1:41 PM	10:41 AM	Same Day	2:41 PM	11:41 AM	Same Day	3:41 PM	12:41 PM	Same Day	4:41 PM
Friday	9:42 AM	Same Day	1:42 PM	10:42 AM	Same Day	2:42 PM	11:42 AM	Same Day	3:42 PM	12:42 PM	Same Day	4:42 PM
Friday	9:43 AM	Same Day	1:43 PM	10:43 AM	Same Day	2:43 PM	11:43 AM	Same Day	3:43 PM	12:43 PM	Same Day	4:43 PM
Friday	9:44 AM	Same Day	1:44 PM	10:44 AM	Same Day	2:44 PM	11:44 AM	Same Day	3:44 PM	12:44 PM	Same Day	4:44 PM
Friday	9:45 AM	Same Day	1:45 PM	10:45 AM	Same Day	2:45 PM	11:45 AM	Same Day	3:45 PM	12:45 PM	Same Day	4:45 PM
Friday	9:46 AM	Same Day	1:46 PM	10:46 AM	Same Day	2:46 PM	11:46 AM	Same Day	3:46 PM	12:46 PM	Same Day	4:46 PM
Friday	9:47 AM	Same Day	1:47 PM	10:47 AM	Same Day	2:47 PM	11:47 AM	Same Day	3:47 PM	12:47 PM	Same Day	4:47 PM
Friday	9:48 AM	Same Day	1:48 PM	10:48 AM	Same Day	2:48 PM	11:48 AM	Same Day	3:48 PM	12:48 PM	Same Day	4:48 PM
Friday	9:49 AM	Same Day	1:49 PM	10:49 AM	Same Day	2:49 PM	11:49 AM	Same Day	3:49 PM	12:49 PM	Same Day	4:49 PM
Friday	9:50 AM	Same Day	1:50 PM	10:50 AM	Same Day	2:50 PM	11:50 AM	Same Day	3:50 PM	12:50 PM	Same Day	4:50 PM
Friday	9:51 AM	Same Day	1:51 PM	10:51 AM	Same Day	2:51 PM	11:51 AM	Same Day	3:51 PM	12:51 PM	Same Day	4:51 PM
Friday	9:52 AM	Same Day	1:52 PM	10:52 AM	Same Day	2:52 PM	11:52 AM	Same Day	3:52 PM	12:52 PM	Same Day	4:52 PM
Friday	9:53 AM	Same Day	1:53 PM	10:53 AM	Same Day	2:53 PM	11:53 AM	Same Day	3:53 PM	12:53 PM	Same Day	4:53 PM
Friday	9:54 AM	Same Day	1:54 PM	10:54 AM	Same Day	2:54 PM	11:54 AM	Same Day	3:54 PM	12:54 PM	Same Day	4:54 PM
Friday	9:55 AM	Same Day	1:55 PM	10:55 AM	Same Day	2:55 PM	11:55 AM	Same Day	3:55 PM	12:55 PM	Same Day	4:55 PM
Friday	9:56 AM	Same Day	1:56 PM	10:56 AM	Same Day	2:56 PM	11:56 AM	Same Day	3:56 PM	12:56 PM	Same Day	4:56 PM
Friday	9:57 AM	Same Day	1:57 PM	10:57 AM	Same Day	2:57 PM	11:57 AM	Same Day	3:57 PM	12:57 PM	Same Day	4:57 PM
Friday	9:58 AM	Same Day	1:58 PM	10:58 AM	Same Day	2:58 PM	11:58 AM	Same Day	3:58 PM	12:58 PM	Same Day	4:58 PM
Friday	9:59 AM	Same Day	1:59 PM	10:59 AM	Same Day	2:59 PM	11:59 AM	Same Day	3:59 PM	12:59 PM	Same Day	4:59 PM
Friday	10:00 AM	Same Day	2:00 PM	11:00 AM	Same Day	3:00 PM	12:00 PM	Same Day	4:00 PM	**1:00 PM**	**Same Day**	**5:00 PM**

Day	Time-In	Expiry By ...		Time-In	Expiry By ...		Time-In	Expiry By ...		Time-In	Expiry By ...		Time-In	Expiry By ...	
Friday	**1:00 PM**	**Day**	**5:00 PM**	2:00 PM	Mon	10:00 AM	3:00 PM	Mon	11:00 AM	4:00 PM	Mon	12:00 PM	5:00 PM	Mon	1:00 PM
Friday	**1:01 PM**	**Mon**	**9:01 AM**	2:01 PM	Mon	10:01 AM	3:01 PM	Mon	11:01 AM	4:01 PM	Mon	12:01 PM	5:01 PM	Mon	1:00 PM
Friday	1:02 PM	Mon	9:02 AM	2:02 PM	Mon	10:02 AM	3:02 PM	Mon	11:02 AM	4:02 PM	Mon	12:02 PM	5:02 PM	Mon	1:00 PM
Friday	1:03 PM	Mon	9:03 AM	2:03 PM	Mon	10:03 AM	3:03 PM	Mon	11:03 AM	4:03 PM	Mon	12:03 PM	5:03 PM	Mon	1:00 PM
Friday	1:04 PM	Mon	9:04 AM	2:04 PM	Mon	10:04 AM	3:04 PM	Mon	11:04 AM	4:04 PM	Mon	12:04 PM	5:04 PM	Mon	1:00 PM
Friday	1:05 PM	Mon	9:05 AM	2:05 PM	Mon	10:05 AM	3:05 PM	Mon	11:05 AM	4:05 PM	Mon	12:05 PM	5:05 PM	Mon	1:00 PM
Friday	1:06 PM	Mon	9:06 AM	2:06 PM	Mon	10:06 AM	3:06 PM	Mon	11:06 AM	4:06 PM	Mon	12:06 PM	:	Mon	1:00 PM
Friday	1:07 PM	Mon	9:07 AM	2:07 PM	Mon	10:07 AM	3:07 PM	Mon	11:07 AM	4:07 PM	Mon	12:07 PM	:	Mon	1:00 PM
Friday	1:08 PM	Mon	9:08 AM	2:08 PM	Mon	10:08 AM	3:08 PM	Mon	11:08 AM	4:08 PM	Mon	12:08 PM	5:55 PM	Mon	1:00 PM
Friday	1:09 PM	Mon	9:09 AM	2:09 PM	Mon	10:09 AM	3:09 PM	Mon	11:09 AM	4:09 PM	Mon	12:09 PM	5:56 PM	Mon	1:00 PM
Friday	1:10 PM	Mon	9:10 AM	2:10 PM	Mon	10:10 AM	3:10 PM	Mon	11:10 AM	4:10 PM	Mon	12:10 PM	5:57 PM	Mon	1:00 PM
Friday	1:11 PM	Mon	9:11 AM	2:11 PM	Mon	10:11 AM	3:11 PM	Mon	11:11 AM	4:11 PM	Mon	12:11 PM	5:58 PM	Mon	1:00 PM
Friday	1:12 PM	Mon	9:12 AM	2:12 PM	Mon	10:12 AM	3:12 PM	Mon	11:12 AM	4:12 PM	Mon	12:12 PM	5:59 PM	Mon	1:00 PM
Friday	1:13 PM	Mon	9:13 AM	2:13 PM	Mon	10:13 AM	3:13 PM	Mon	11:13 AM	4:13 PM	Mon	12:13 PM	6:00 PM	Mon	1:00 PM
Friday	1:14 PM	Mon	9:14 AM	2:14 PM	Mon	10:14 AM	3:14 PM	Mon	11:14 AM	4:14 PM	Mon	12:14 PM	6:01 PM	Mon	1:00 PM
Friday	1:15 PM	Mon	9:15 AM	2:15 PM	Mon	10:15 AM	3:15 PM	Mon	11:15 AM	4:15 PM	Mon	12:15 PM	6:02 PM	Mon	1:00 PM
Friday	1:16 PM	Mon	9:16 AM	2:16 PM	Mon	10:16 AM	3:16 PM	Mon	11:16 AM	4:16 PM	Mon	12:16 PM	6:03 PM	Mon	1:00 PM
Friday	1:17 PM	Mon	9:17 AM	2:17 PM	Mon	10:17 AM	3:17 PM	Mon	11:17 AM	4:17 PM	Mon	12:17 PM	6:04 PM	Mon	1:00 PM
Friday	1:18 PM	Mon	9:18 AM	2:18 PM	Mon	10:18 AM	3:18 PM	Mon	11:18 AM	4:18 PM	Mon	12:18 PM	6:05 PM	Mon	1:00 PM
Friday	1:19 PM	Mon	9:19 AM	2:19 PM	Mon	10:19 AM	3:19 PM	Mon	11:19 AM	4:19 PM	Mon	12:19 PM	:	Mon	1:00 PM
Friday	1:20 PM	Mon	9:20 AM	2:20 PM	Mon	10:20 AM	3:20 PM	Mon	11:20 AM	4:20 PM	Mon	12:20 PM	:	Mon	1:00 PM
Friday	1:21 PM	Mon	9:21 AM	2:21 PM	Mon	10:21 AM	3:21 PM	Mon	11:21 AM	4:21 PM	Mon	12:21 PM	6:55 PM	Mon	1:00 PM
Friday	1:22 PM	Mon	9:22 AM	2:22 PM	Mon	10:22 AM	3:22 PM	Mon	11:22 AM	4:22 PM	Mon	12:22 PM	6:56 PM	Mon	1:00 PM
Friday	1:23 PM	Mon	9:23 AM	2:23 PM	Mon	10:23 AM	3:23 PM	Mon	11:23 AM	4:23 PM	Mon	12:23 PM	6:57 PM	Mon	1:00 PM
Friday	1:24 PM	Mon	9:24 AM	2:24 PM	Mon	10:24 AM	3:24 PM	Mon	11:24 AM	4:24 PM	Mon	12:24 PM	6:58 PM	Mon	1:00 PM
Friday	1:25 PM	Mon	9:25 AM	2:25 PM	Mon	10:25 AM	3:25 PM	Mon	11:25 AM	4:25 PM	Mon	12:25 PM	6:59 PM	Mon	1:00 PM
Friday	1:26 PM	Mon	9:26 AM	2:26 PM	Mon	10:26 AM	3:26 PM	Mon	11:26 AM	4:26 PM	Mon	12:26 PM	7:00 PM	Mon	1:00 PM
Friday	1:27 PM	Mon	9:27 AM	2:27 PM	Mon	10:27 AM	3:27 PM	Mon	11:27 AM	4:27 PM	Mon	12:27 PM	7:01 PM	Mon	1:00 PM
Friday	1:28 PM	Mon	9:28 AM	2:28 PM	Mon	10:28 AM	3:28 PM	Mon	11:28 AM	4:28 PM	Mon	12:28 PM	7:02 PM	Mon	1:00 PM
Friday	1:29 PM	Mon	9:29 AM	2:29 PM	Mon	10:29 AM	3:29 PM	Mon	11:29 AM	4:29 PM	Mon	12:29 PM	7:03 PM	Mon	1:00 PM
Friday	1:30 PM	Mon	9:30 AM	2:30 PM	Mon	10:30 AM	3:30 PM	Mon	11:30 AM	4:30 PM	Mon	12:30 PM	7:04 PM	Mon	1:00 PM
Friday	1:31 PM	Mon	9:31 AM	2:31 PM	Mon	10:31 AM	3:31 PM	Mon	11:31 AM	4:31 PM	Mon	12:31 PM	7:05 PM	Mon	1:00 PM
Friday	1:32 PM	Mon	9:32 AM	2:32 PM	Mon	10:32 AM	3:32 PM	Mon	11:32 AM	4:32 PM	Mon	12:32 PM	:	Mon	1:00 PM
Friday	1:33 PM	Mon	9:33 AM	2:33 PM	Mon	10:33 AM	3:33 PM	Mon	11:33 AM	4:33 PM	Mon	12:33 PM	:	Mon	1:00 PM
Friday	1:34 PM	Mon	9:34 AM	2:34 PM	Mon	10:34 AM	3:34 PM	Mon	11:34 AM	4:34 PM	Mon	12:34 PM	7:55 PM	Mon	1:00 PM
Friday	1:35 PM	Mon	9:35 AM	2:35 PM	Mon	10:35 AM	3:35 PM	Mon	11:35 AM	4:35 PM	Mon	12:35 PM	7:56 PM	Mon	1:00 PM
Friday	1:36 PM	Mon	9:36 AM	2:36 PM	Mon	10:36 AM	3:36 PM	Mon	11:36 AM	4:36 PM	Mon	12:36 PM	7:57 PM	Mon	1:00 PM
Friday	1:37 PM	Mon	9:37 AM	2:37 PM	Mon	10:37 AM	3:37 PM	Mon	11:37 AM	4:37 PM	Mon	12:37 PM	7:58 PM	Mon	1:00 PM
Friday	1:38 PM	Mon	9:38 AM	2:38 PM	Mon	10:38 AM	3:38 PM	Mon	11:38 AM	4:38 PM	Mon	12:38 PM	7:59 PM	Mon	1:00 PM
Friday	1:39 PM	Mon	9:39 AM	2:39 PM	Mon	10:39 AM	3:39 PM	Mon	11:39 AM	4:39 PM	Mon	12:39 PM	8:00 PM	Mon	1:00 PM
Friday	1:40 PM	Mon	9:40 AM	2:40 PM	Mon	10:40 AM	3:40 PM	Mon	11:40 AM	4:40 PM	Mon	12:40 PM	8:01 PM	Mon	1:00 PM
Friday	1:41 PM	Mon	9:41 AM	2:41 PM	Mon	10:41 AM	3:41 PM	Mon	11:41 AM	4:41 PM	Mon	12:41 PM	8:02 PM	Mon	1:00 PM
Friday	1:42 PM	Mon	9:42 AM	2:42 PM	Mon	10:42 AM	3:42 PM	Mon	11:42 AM	4:42 PM	Mon	12:42 PM	8:03 PM	Mon	1:00 PM
Friday	1:43 PM	Mon	9:43 AM	2:43 PM	Mon	10:43 AM	3:43 PM	Mon	11:43 AM	4:43 PM	Mon	12:43 PM	8:04 PM	Mon	1:00 PM
Friday	1:44 PM	Mon	9:44 AM	2:44 PM	Mon	10:44 AM	3:44 PM	Mon	11:44 AM	4:44 PM	Mon	12:44 PM	8:05 PM	Mon	1:00 PM
Friday	1:45 PM	Mon	9:45 AM	2:45 PM	Mon	10:45 AM	3:45 PM	Mon	11:45 AM	4:45 PM	Mon	12:45 PM	:	Mon	1:00 PM
Friday	1:46 PM	Mon	9:46 AM	2:46 PM	Mon	10:46 AM	3:46 PM	Mon	11:46 AM	4:46 PM	Mon	12:46 PM	:	Mon	1:00 PM
Friday	1:47 PM	Mon	9:47 AM	2:47 PM	Mon	10:47 AM	3:47 PM	Mon	11:47 AM	4:47 PM	Mon	12:47 PM	8:55 PM	Mon	1:00 PM
Friday	1:48 PM	Mon	9:48 AM	2:48 PM	Mon	10:48 AM	3:48 PM	Mon	11:48 AM	4:48 PM	Mon	12:48 PM	8:56 PM	Mon	1:00 PM
Friday	1:49 PM	Mon	9:49 AM	2:49 PM	Mon	10:49 AM	3:49 PM	Mon	11:49 AM	4:49 PM	Mon	12:49 PM	8:57 PM	Mon	1:00 PM
Friday	1:50 PM	Mon	9:50 AM	2:50 PM	Mon	10:50 AM	3:50 PM	Mon	11:50 AM	4:50 PM	Mon	12:50 PM	8:58 PM	Mon	1:00 PM
Friday	1:51 PM	Mon	9:51 AM	2:51 PM	Mon	10:51 AM	3:51 PM	Mon	11:51 AM	4:51 PM	Mon	12:51 PM	8:59 PM	Mon	1:00 PM
Friday	1:52 PM	Mon	9:52 AM	2:52 PM	Mon	10:52 AM	3:52 PM	Mon	11:52 AM	4:52 PM	Mon	12:52 PM	9:00 PM	Mon	1:00 PM
Friday	1:53 PM	Mon	9:53 AM	2:53 PM	Mon	10:53 AM	3:53 PM	Mon	11:53 AM	4:53 PM	Mon	12:53 PM	9:01 PM	Mon	1:00 PM
Friday	1:54 PM	Mon	9:54 AM	2:54 PM	Mon	10:54 AM	3:54 PM	Mon	11:54 AM	4:54 PM	Mon	12:54 PM	9:02 PM	Mon	1:00 PM
Friday	1:55 PM	Mon	9:55 AM	2:55 PM	Mon	10:55 AM	3:55 PM	Mon	11:55 AM	4:55 PM	Mon	12:55 PM	9:03 PM	Mon	1:00 PM
Friday	1:56 PM	Mon	9:56 AM	2:56 PM	Mon	10:56 AM	3:56 PM	Mon	11:56 AM	4:56 PM	Mon	12:56 PM	9:04 PM	Mon	1:00 PM
Friday	1:57 PM	Mon	9:57 AM	2:57 PM	Mon	10:57 AM	3:57 PM	Mon	11:57 AM	4:57 PM	Mon	12:57 PM	9:05 PM	Mon	1:00 PM
Friday	1:58 PM	Mon	9:58 AM	2:58 PM	Mon	10:58 AM	3:58 PM	Mon	11:58 AM	4:58 PM	Mon	12:58 PM	9:06 PM	Mon	1:00 PM
Friday	1:59 PM	Mon	9:59 AM	2:59 PM	Mon	10:59 AM	3:59 PM	Mon	11:59 AM	4:59 PM	Mon	12:59 PM	:	Mon	1:00 PM
Friday	2:00 PM	Mon	10:00 AM	3:00 PM	Mon	11:00 AM	4:00 PM	Mon	12:00 PM	5:00 PM	Mon	1:00 PM	:	Mon	1:00 PM

Day	Time-In	Expiry By …		Time-In	Expiry By …		Time-In	Expiry By …		Time-In	Expiry By …	
Sat…Sun	9:00 AM	Mon	1:00 PM	10:00 AM	Mon	1:00 PM	11:00 AM	Mon	1:00 PM	12:00 PM	Mon	1:00 PM
Sat…Sun	9:01 AM	Mon	1:00 PM	10:01 AM	Mon	1:00 PM	11:01 AM	Mon	1:00 PM	12:01 PM	Mon	1:00 PM
Sat…Sun	9:02 AM	Mon	1:00 PM	10:02 AM	Mon	1:00 PM	11:02 AM	Mon	1:00 PM	12:02 PM	Mon	1:00 PM
Sat…Sun	9:03 AM	Mon	1:00 PM	10:03 AM	Mon	1:00 PM	11:03 AM	Mon	1:00 PM	12:03 PM	Mon	1:00 PM
Sat…Sun	9:04 AM	Mon	1:00 PM	10:04 AM	Mon	1:00 PM	11:04 AM	Mon	1:00 PM	12:04 PM	Mon	1:00 PM
Sat…Sun	9:05 AM	Mon	1:00 PM	10:05 AM	Mon	1:00 PM	11:05 AM	Mon	1:00 PM	12:05 PM	Mon	1:00 PM
Sat…Sun	9:06 AM	Mon	1:00 PM	10:06 AM	Mon	1:00 PM	11:06 AM	Mon	1:00 PM	12:06 PM	Mon	1:00 PM
Sat…Sun	9:07 AM	Mon	1:00 PM	10:07 AM	Mon	1:00 PM	11:07 AM	Mon	1:00 PM	12:07 PM	Mon	1:00 PM
Sat…Sun	9:08 AM	Mon	1:00 PM	10:08 AM	Mon	1:00 PM	11:08 AM	Mon	1:00 PM	12:08 PM	Mon	1:00 PM
Sat…Sun	9:09 AM	Mon	1:00 PM	10:09 AM	Mon	1:00 PM	11:09 AM	Mon	1:00 PM	12:09 PM	Mon	1:00 PM
Sat…Sun	9:10 AM	Mon	1:00 PM	10:10 AM	Mon	1:00 PM	11:10 AM	Mon	1:00 PM	12:10 PM	Mon	1:00 PM
Sat…Sun	9:11 AM	Mon	1:00 PM	10:11 AM	Mon	1:00 PM	11:11 AM	Mon	1:00 PM	12:11 PM	Mon	1:00 PM
Sat…Sun	9:12 AM	Mon	1:00 PM	10:12 AM	Mon	1:00 PM	11:12 AM	Mon	1:00 PM	12:12 PM	Mon	1:00 PM
Sat…Sun	9:13 AM	Mon	1:00 PM	10:13 AM	Mon	1:00 PM	11:13 AM	Mon	1:00 PM	12:13 PM	Mon	1:00 PM
Sat…Sun	9:14 AM	Mon	1:00 PM	10:14 AM	Mon	1:00 PM	11:14 AM	Mon	1:00 PM	12:14 PM	Mon	1:00 PM
Sat…Sun	9:15 AM	Mon	1:00 PM	10:15 AM	Mon	1:00 PM	11:15 AM	Mon	1:00 PM	12:15 PM	Mon	1:00 PM
Sat…Sun	9:16 AM	Mon	1:00 PM	10:16 AM	Mon	1:00 PM	11:16 AM	Mon	1:00 PM	12:16 PM	Mon	1:00 PM
Sat…Sun	9:17 AM	Mon	1:00 PM	10:17 AM	Mon	1:00 PM	11:17 AM	Mon	1:00 PM	12:17 PM	Mon	1:00 PM
Sat…Sun	9:18 AM	Mon	1:00 PM	10:18 AM	Mon	1:00 PM	11:18 AM	Mon	1:00 PM	12:18 PM	Mon	1:00 PM
Sat…Sun	9:19 AM	Mon	1:00 PM	10:19 AM	Mon	1:00 PM	11:19 AM	Mon	1:00 PM	12:19 PM	Mon	1:00 PM
Sat…Sun	9:20 AM	Mon	1:00 PM	10:20 AM	Mon	1:00 PM	11:20 AM	Mon	1:00 PM	12:20 PM	Mon	1:00 PM
Sat…Sun	9:21 AM	Mon	1:00 PM	10:21 AM	Mon	1:00 PM	11:21 AM	Mon	1:00 PM	12:21 PM	Mon	1:00 PM
Sat…Sun	9:22 AM	Mon	1:00 PM	10:22 AM	Mon	1:00 PM	11:22 AM	Mon	1:00 PM	12:22 PM	Mon	1:00 PM
Sat…Sun	9:23 AM	Mon	1:00 PM	10:23 AM	Mon	1:00 PM	11:23 AM	Mon	1:00 PM	12:23 PM	Mon	1:00 PM
Sat…Sun	9:24 AM	Mon	1:00 PM	10:24 AM	Mon	1:00 PM	11:24 AM	Mon	1:00 PM	12:24 PM	Mon	1:00 PM
Sat…Sun	9:25 AM	Mon	1:00 PM	10:25 AM	Mon	1:00 PM	11:25 AM	Mon	1:00 PM	12:25 PM	Mon	1:00 PM
Sat…Sun	9:26 AM	Mon	1:00 PM	10:26 AM	Mon	1:00 PM	11:26 AM	Mon	1:00 PM	12:26 PM	Mon	1:00 PM
Sat…Sun	9:27 AM	Mon	1:00 PM	10:27 AM	Mon	1:00 PM	11:27 AM	Mon	1:00 PM	12:27 PM	Mon	1:00 PM
Sat…Sun	9:28 AM	Mon	1:00 PM	10:28 AM	Mon	1:00 PM	11:28 AM	Mon	1:00 PM	12:28 PM	Mon	1:00 PM
Sat…Sun	9:29 AM	Mon	1:00 PM	10:29 AM	Mon	1:00 PM	11:29 AM	Mon	1:00 PM	12:29 PM	Mon	1:00 PM
Sat…Sun	9:30 AM	Mon	1:00 PM	10:30 AM	Mon	1:00 PM	11:30 AM	Mon	1:00 PM	12:30 PM	Mon	1:00 PM
Sat…Sun	9:31 AM	Mon	1:00 PM	10:31 AM	Mon	1:00 PM	11:31 AM	Mon	1:00 PM	12:31 PM	Mon	1:00 PM
Sat…Sun	9:32 AM	Mon	1:00 PM	10:32 AM	Mon	1:00 PM	11:32 AM	Mon	1:00 PM	12:32 PM	Mon	1:00 PM
Sat…Sun	9:33 AM	Mon	1:00 PM	10:33 AM	Mon	1:00 PM	11:33 AM	Mon	1:00 PM	12:33 PM	Mon	1:00 PM
Sat…Sun	9:34 AM	Mon	1:00 PM	10:34 AM	Mon	1:00 PM	11:34 AM	Mon	1:00 PM	12:34 PM	Mon	1:00 PM
Sat…Sun	9:35 AM	Mon	1:00 PM	10:35 AM	Mon	1:00 PM	11:35 AM	Mon	1:00 PM	12:35 PM	Mon	1:00 PM
Sat…Sun	9:36 AM	Mon	1:00 PM	10:36 AM	Mon	1:00 PM	11:36 AM	Mon	1:00 PM	12:36 PM	Mon	1:00 PM
Sat…Sun	9:37 AM	Mon	1:00 PM	10:37 AM	Mon	1:00 PM	11:37 AM	Mon	1:00 PM	12:37 PM	Mon	1:00 PM
Sat…Sun	9:38 AM	Mon	1:00 PM	10:38 AM	Mon	1:00 PM	11:38 AM	Mon	1:00 PM	12:38 PM	Mon	1:00 PM
Sat…Sun	9:39 AM	Mon	1:00 PM	10:39 AM	Mon	1:00 PM	11:39 AM	Mon	1:00 PM	12:39 PM	Mon	1:00 PM
Sat…Sun	9:40 AM	Mon	1:00 PM	10:40 AM	Mon	1:00 PM	11:40 AM	Mon	1:00 PM	12:40 PM	Mon	1:00 PM
Sat…Sun	9:41 AM	Mon	1:00 PM	10:41 AM	Mon	1:00 PM	11:41 AM	Mon	1:00 PM	12:41 PM	Mon	1:00 PM
Sat…Sun	9:42 AM	Mon	1:00 PM	10:42 AM	Mon	1:00 PM	11:42 AM	Mon	1:00 PM	12:42 PM	Mon	1:00 PM
Sat…Sun	9:43 AM	Mon	1:00 PM	10:43 AM	Mon	1:00 PM	11:43 AM	Mon	1:00 PM	12:43 PM	Mon	1:00 PM
Sat…Sun	9:44 AM	Mon	1:00 PM	10:44 AM	Mon	1:00 PM	11:44 AM	Mon	1:00 PM	12:44 PM	Mon	1:00 PM
Sat…Sun	9:45 AM	Mon	1:00 PM	10:45 AM	Mon	1:00 PM	11:45 AM	Mon	1:00 PM	12:45 PM	Mon	1:00 PM
Sat…Sun	9:46 AM	Mon	1:00 PM	10:46 AM	Mon	1:00 PM	11:46 AM	Mon	1:00 PM	12:46 PM	Mon	1:00 PM
Sat…Sun	9:47 AM	Mon	1:00 PM	10:47 AM	Mon	1:00 PM	11:47 AM	Mon	1:00 PM	12:47 PM	Mon	1:00 PM
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Sat…Sun	10:00 AM	Mon	1:00 PM	11:00 AM	Mon	1:00 PM	12:00 PM	Mon	1:00 PM	1:00 PM	Mon	1:00 PM

Day	Time-In	Expiry By …		Time-In	Expiry By …		Time-In	Expiry By …		Time-In	Expiry By …		Time-In	Expiry By …	
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Sat…Sun	1:08 PM	Mon	1:00 PM	2:08 PM	Mon	1:00 PM	3:08 PM	Mon	1:00 PM	4:08 PM	Mon	1:00 PM	5:55 PM	Mon	1:00 PM
Sat…Sun	1:09 PM	Mon	1:00 PM	2:09 PM	Mon	1:00 PM	3:09 PM	Mon	1:00 PM	4:09 PM	Mon	1:00 PM	5:56 PM	Mon	1:00 PM
Sat…Sun	1:10 PM	Mon	1:00 PM	2:10 PM	Mon	1:00 PM	3:10 PM	Mon	1:00 PM	4:10 PM	Mon	1:00 PM	5:57 PM	Mon	1:00 PM
Sat…Sun	1:11 PM	Mon	1:00 PM	2:11 PM	Mon	1:00 PM	3:11 PM	Mon	1:00 PM	4:11 PM	Mon	1:00 PM	5:58 PM	Mon	1:00 PM
Sat…Sun	1:12 PM	Mon	1:00 PM	2:12 PM	Mon	1:00 PM	3:12 PM	Mon	1:00 PM	4:12 PM	Mon	1:00 PM	5:59 PM	Mon	1:00 PM
Sat…Sun	1:13 PM	Mon	1:00 PM	2:13 PM	Mon	1:00 PM	3:13 PM	Mon	1:00 PM	4:13 PM	Mon	1:00 PM	6:00 PM	Mon	1:00 PM
Sat…Sun	1:14 PM	Mon	1:00 PM	2:14 PM	Mon	1:00 PM	3:14 PM	Mon	1:00 PM	4:14 PM	Mon	1:00 PM	6:01 PM	Mon	1:00 PM
Sat…Sun	1:15 PM	Mon	1:00 PM	2:15 PM	Mon	1:00 PM	3:15 PM	Mon	1:00 PM	4:15 PM	Mon	1:00 PM	6:02 PM	Mon	1:00 PM
Sat…Sun	1:16 PM	Mon	1:00 PM	2:16 PM	Mon	1:00 PM	3:16 PM	Mon	1:00 PM	4:16 PM	Mon	1:00 PM	6:03 PM	Mon	1:00 PM
Sat…Sun	1:17 PM	Mon	1:00 PM	2:17 PM	Mon	1:00 PM	3:17 PM	Mon	1:00 PM	4:17 PM	Mon	1:00 PM	6:04 PM	Mon	1:00 PM
Sat…Sun	1:18 PM	Mon	1:00 PM	2:18 PM	Mon	1:00 PM	3:18 PM	Mon	1:00 PM	4:18 PM	Mon	1:00 PM	6:05 PM	Mon	1:00 PM
Sat…Sun	1:19 PM	Mon	1:00 PM	2:19 PM	Mon	1:00 PM	3:19 PM	Mon	1:00 PM	4:19 PM	Mon	1:00 PM	:	Mon	1:00 PM
Sat…Sun	1:20 PM	Mon	1:00 PM	2:20 PM	Mon	1:00 PM	3:20 PM	Mon	1:00 PM	4:20 PM	Mon	1:00 PM	:	Mon	1:00 PM
Sat…Sun	1:21 PM	Mon	1:00 PM	2:21 PM	Mon	1:00 PM	3:21 PM	Mon	1:00 PM	4:21 PM	Mon	1:00 PM	6:55 PM	Mon	1:00 PM
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Sat…Sun	1:46 PM	Mon	1:00 PM	2:46 PM	Mon	1:00 PM	3:46 PM	Mon	1:00 PM	4:46 PM	Mon	1:00 PM	:	Mon	1:00 PM
Sat…Sun	1:47 PM	Mon	1:00 PM	2:47 PM	Mon	1:00 PM	3:47 PM	Mon	1:00 PM	4:47 PM	Mon	1:00 PM	8:55 PM	Mon	1:00 PM
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Sat…Sun	1:54 PM	Mon	1:00 PM	2:54 PM	Mon	1:00 PM	3:54 PM	Mon	1:00 PM	4:54 PM	Mon	1:00 PM	9:02 PM	Mon	1:00 PM
Sat…Sun	1:55 PM	Mon	1:00 PM	2:55 PM	Mon	1:00 PM	3:55 PM	Mon	1:00 PM	4:55 PM	Mon	1:00 PM	9:03 PM	Mon	1:00 PM
Sat…Sun	1:56 PM	Mon	1:00 PM	2:56 PM	Mon	1:00 PM	3:56 PM	Mon	1:00 PM	4:56 PM	Mon	1:00 PM	9:04 PM	Mon	1:00 PM
Sat…Sun	1:57 PM	Mon	1:00 PM	2:57 PM	Mon	1:00 PM	3:57 PM	Mon	1:00 PM	4:57 PM	Mon	1:00 PM	9:05 PM	Mon	1:00 PM
Sat…Sun	1:58 PM	Mon	1:00 PM	2:58 PM	Mon	1:00 PM	3:58 PM	Mon	1:00 PM	4:58 PM	Mon	1:00 PM	9:06 PM	Mon	1:00 PM
Sat…Sun	1:59 PM	Mon	1:00 PM	2:59 PM	Mon	1:00 PM	3:59 PM	Mon	1:00 PM	4:59 PM	Mon	1:00 PM	:	Mon	1:00 PM
Sat…Sun	2:00 PM	Mon	1:00 PM	3:00 PM	Mon	1:00 PM	4:00 PM	Mon	1:00 PM	5:00 PM	Mon	1:00 PM	:	Mon	1:00 PM

Appendix-4 Questionnaire: Kerzner's Project Management Maturity and Project Management Excellence

Questionnaire: Case Study Project Management Maturity and Project Management Excellence Survey

Q1 Good morning/afternoon/evening. We are academic researchers from the University of Nottingham (Malaysia Campus). We are currently conducting a study understanding the "project management maturity level" and "project management excellence" of the IT organizations in Malaysia. We kindly request your help in completing the following short questionnaire regarding your organization. Your help is greatly appreciated and your prompt response and timely completion of the survey will be one of the keys contribute to this survey success. We would be much happy to share the results if you need. You may choose NOT to enter your details on the questionnaire to remain anonymous. This questionnaire should take no longer than 15 minutes of your time. Your response is of the utmost importance to us.

Q2 RESPONDENT'S DETAILS

Respondent's Name ____

Company Name ____

Department/Division ____

Company Address ____

Q3 The organization business nature:
- ❍ IT Software House
- ❍ Consultation Service
- ❍ IT Service Provider
- ❍ Hardware Retailer
- ❍ Hardware Manufacturer
- ❍ Software Distributor
- ❍ Others, please specify... ____________________

Q4 The number of employees in the organization:
- ❍ < 5
- ❍ 5 - 19
- ❍ 20 - 50
- ❍ 50 - 100
- ❍ 100 - 200
- ❍ Other, please specify... ____________________

Q5 The number of years the company has been in business:
- ❍ < 1 year
- ❍ 1 - 3 years
- ❍ 3 - 5 years
- ❍ 5 - 8 years
- ❍ 8 - 10 years
- ❍ 10 - 15 years
- ❍ 15 - 20 years
- ❍ Other, please specify... ____________________

Q6 Overall in your opinion, the organization is currently at the level of ___________________in project management maturity level:
- ❍ Immature (1)
- ❍ (2)
- ❍ (3)
- ❍ (4)
- ❍ Matured (5)

Q7 How do you see your organization achievement in the context of project management excellence?
- ❍ The company has no understanding of project management, nor does it appear that the company wishes to change
- ❍ The company is probably just providing lip service to project management. Support is minimal. The company is still a functional organization
- ❍ The company is going in the right direction, but more work is still needed. Project management is not totally perceived as profession
- ❍ The company compares very well to the other competitors companies within the same industry

Q8 Your Role / Designation in the organization:
- ❍ Business Owner
- ❍ Project Director
- ❍ Project Manager
- ❍ Quality Manager
- ❍ Consultant
- ❍ System Analyst
- ❍ Software Engineer / Developer / Architect
- ❍ System Administrator
- ❍ Business Analyst
- ❍ Other, please specify... ____________________

Q9 Your working experience in current position:
- ❍ < 1 year
- ❍ 1 - 3 years
- ❍ 5 - 7 years
- ❍ 7 - 10 years
- ❍ 3 - 5 years
- ❍ Other, please specify... ____________________

Q10 Project Scope Management, Time Management, Cost Management, Quality Management, Human Resource Management, Communication Management, Risk Management, Procurement Management and Integration Management are the nine basic knowledge areas for IT Project Management. In general, how would you view your project team's capability in these Project Management Knowledge areas?

	Very Poor	Poor	Fair	Good	Very Good
Project Team Member(s)	❍	❍	❍	❍	❍
Project Leader(s)	❍	❍	❍	❍	❍
Project Manager(s)	❍	❍	❍	❍	❍

Q11 The sanctioned project team direction is crucial in avoiding conflicts of priorities among project team members. Generally, how would you view your team's directive in:

Company Vision and Mission	❍ Not at all Concerned (1)	❍ (2)	❍ (3)	❍ (4)	❍ Extremely Concerned (5)
Project Goals and Project Objectives	❍ Not at all Concerned (1)	❍ (2)	❍ (3)	❍ (4)	❍ Extremely Concerned (5)
On-Time Project Delivery	❍ Low Importance (1)	❍ (2)	❍ (3)	❍ (4)	❍ Slightly Important (5)
Project Documentation Configuration Management	❍ Strongly Oppose	❍ Somewhat Oppose	❍ Neutral	❍ Somewhat Support	❍ Strongly Support

Q12 What is the level of accountability of recognition by the project team in accepting accountability for their actions in project management activities?

	Accountable (5)	(4)	(3)	(2)	Not Accountable (1)
SLA / OLA (Service Level Agreement / Operation Level Agreement)	❍	❍	❍	❍	❍
User Requirement	❍	❍	❍	❍	❍
Project Schedule	❍	❍	❍	❍	❍
Project Quality	❍	❍	❍	❍	❍
Project Cost	❍	❍	❍	❍	❍

Q13 It is important to account qualitatively and quantitatively for the human factor to verify the level of project integrity, project leadership and project commitment within the project team.

	Dissatisfy (1)	(2)	(3)	(4)	Very Satisfy (5)
Project Integrity	❍	❍	❍	❍	❍
Project Leadership	❍	❍	❍	❍	❍
Project Commitment	❍	❍	❍	❍	❍

Q14 Organizations often fail in their change effort and improvement efforts because of their inability to bring about culture change. In general, to what level of cultural change the organization can adapt:

	Very Difficult	Difficult	Somewhat Difficult	Somewhat Easy	Easy	Very Easy
Team Collaboration	❍	❍	❍	❍	❍	❍
Team Creativity	❍	❍	❍	❍	❍	❍
Team Controlling	❍	❍	❍	❍	❍	❍
Team Competing	❍	❍	❍	❍	❍	❍

Q15 My company recognizes the need for project management. This need is recognised at all levels of management, including senior management :

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Slightly Disagree
- ❍ No Opinion
- ❍ Slightly Agree
- ❍ Agree
- ❍ Strongly Agree

Q16 My company has a system in place to manage cost and schedule. The system requires charge numbers and cost account codes. The system reports variances from planned targets :

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Slightly Disagree
- ❍ No Opinion
- ❍ Slightly Agree
- ❍ Agree
- ❍ Strongly Agree

Q17 My company has recognizes the benefits that are possible from implementing project management. These benefits have been recognized at all level of management, including senior management.
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q18 My company (or division) has a well-definable Project Management methodology using life cycle phases :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q19 Our executives visibly support project management through executive presentation, correspondence, and by occasionally attending project team meeting/ briefings :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q20 My company is committed to quality up-front planning. We try to do the best we can at planning :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q21 Our lower- and middle- level line managers totally & visibly support project management process :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q22 My company is doing everything possible to minimize "creeping" scope (i.e. scope changes) on our project :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q23 Our line managers are committed not only to project management, but also to the promises made to project management for deliverables :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q24 The executives in my organization have a good understanding of principles in project management :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q25 The company has selected one or more project management software package to be used as the project tracking system :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q26 Our lower- and middle- level line managers have been trained & educated in project management :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q27 Our executives understand both project sponsorship and serve as project sponsors on selected projects :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q28 My executive have recognized or identified the applications of project management to various parts of business :
- Strongly Disagree
- Disagree
- Slightly Disagree
- No Opinion
- Slightly Agree
- Agree
- Strongly Agree

Q29 My company has successfully integrated cost and schedule cost control together for both managing project and reporting status :
- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Slightly Disagree
- ❍ No Opinion
- ❍ Slightly Agree
- ❍ Agree
- ❍ Strongly Agree

Q30 My company has developed a project management curriculum (i.e., more than one or two courses) to enhance the project management skills of employees :
- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Slightly Disagree
- ❍ No Opinion
- ❍ Slightly Agree
- ❍ Agree
- ❍ Strongly Agree

Q31 Our executives have recognized what must be done in order to achieve maturity in project management :
- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Slightly Disagree
- ❍ No Opinion
- ❍ Slightly Agree
- ❍ Agree
- ❍ Strongly Agree

Q32 Our company views and treats project management as professions rather than part-time assignment :
- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Slightly Disagree
- ❍ No Opinion
- ❍ Slightly Agree
- ❍ Agree
- ❍ Strongly Agree

Q33 Our lower- and middle- level line managers are willing to release their employees for project management training :
- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Slightly Disagree
- ❍ No Opinion
- ❍ Slightly Agree
- ❍ Agree
- ❍ Strongly Agree

Q34 Our executives have demonstrated a willingness to change the way of doing business in order to mature in project management :
- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Slightly Disagree
- ❍ No Opinion
- ❍ Slightly Agree
- ❍ Agree
- ❍ Strongly Agree

Q35 How do you view your company direction?
- ❍ My company never set any vision, mission or goals
- ❍ My company has a vision, mission or goal but no guideline provided
- ❍ My company has a vision, mission or goals but the information provided is too complicated
- ❍ My company has a vision, mission or goals but there is communication problems
- ❍ My company has a clear and excellence vision, mission and goals to follow

Q36 In your view, what is the category of culture of your company?
- ❍ Cooperative culture (based on trust and effective communication)
- ❍ Non-cooperative culture (based on personal interest)
- ❍ Competitive culture (based on competition inside project team)
- ❍ Isolated culture (culture within culture environment)
- ❍ Fragmented culture (where part of the team is separated from the rest of the team)

Q37 How does your company sees the benefits of implementation of project management: (You may select more than one answer) :
- ❑ Improving company performance
- ❑ Reducing cost of operation
- ❑ Increasing company profit
- ❑ Wasting time and money

Q38 Your company actively uses the following processes:
- ❍ Totally quality management (TQM) only
- ❍ Concurrent engineering (shortening deliverable development time) only
- ❍ TQM and concurrent engineering only
- ❍ Risk management only
- ❍ Risk management and concurrent engineering only
- ❍ Risk management, concurrent engineering, and TQM

Q39 On what percent of your projects do you use the principles of total quality management?
- ❍ 0%
- ❍ 5 – 10%
- ❍ 10 – 25%
- ❍ 25 – 50%
- ❍ 50 – 75%
- ❍ 75 – 100%

Q40 On what percent of your projects do you use the principles of risk management?
- ❍ 0%
- ❍ 5 – 10%
- ❍ 10 – 25%
- ❍ 25 – 50%
- ❍ 50 – 75%
- ❍ 75 – 100%

Q41 On what percentage of your projects do you try to compress product/ deliverable schedules by performing work in parallel rather than in series?
- ❍ 0%
- ❍ 5 – 10%
- ❍ 10 – 25%
- ❍ 25 – 50%
- ❍ 50 – 75%
- ❍ 75 – 100%

Q42 Your company's risk management process is based upon:
- You do not use risk management
- Financial risks only
- Technical risks only
- Scheduling risks only
- A combination of financial, technical and scheduling risks based upon the project

Q43 The risk management methodology in your company is:
- Nonexistent
- More informal than formal
- Based upon a structured methodology supported by policies and procedures
- Based upon a structured methodology supported by policies, procedures, and standardized forms to be completed

Q44 How many different project management methodologies exist in your organization (i.e. consider a systems development methodology for MIS projects different than a product development project management methodology)?
- No methodologies
- 1
- 2-3
- 4-5
- More than 5

Q45 With regards to benchmarking:
- Your company has never tried to use benchmarking
- Your company has performed benchmarking and implemented changes but not for project management
- Your company has performed project management benchmarking but no changes were made
- Your company has performed project management benchmarking and changes were made

Q46 Which of the following best describes your corporate culture?
- Single-boss reporting
- Multiple-boss reporting
- Dedicated teams without empowerment
- Non-dedicated teams without empowerment
- Dedicated teams with empowerment
- Non-dedicated teams with empowerment

Q47 With regard to morals and ethics, your company believes that:
- The customer is always right
- Decisions should be made in the following sequence: best interest of the customer first, then the company, then the employees
- Decisions should be made in the following sequence: best interest of company first, customer second, and the employees last
- Your company has no such written policy or set of standards

Q48 Your company conducts internal training courses on:
- Morality and ethics within the company
- Morality and ethics in dealing with customers
- Good business practices
- All of the above
- None of the above
- At least two of the first three

Q49 With regards to scope creep or scope changes, your culture:
- Discourages change after project initiation
- Allows changes only up to a certain point in the project's life cycle using a formal change control process
- Allows changes anywhere in the project life cycle using a formal changes control process
- Allows changes but without any formal control process

Q50 Your culture seems to be based upon:
- Policies
- Procedures (including forms to be filled out)
- Policies and procedures
- Guidelines
- Policies, procedures, and guidelines

Q51 Culture are either quantitative (policies, procedures, forms, and guidelines), behavioral, or a compromise. The culture in your company is probably ________________________________ percent behavioral.
- 10 - 25
- 25 - 50
- 50 - 60
- 60 - 75
- Greater than 75

Q52 Your organizational structure is:
- Traditional (predominantly vertical)
- A strong matrix (i.e., project manager provides most of the technical direction)
- A weak matrix (i.e., line managers provide most of the of the technical direction)
- We use co-located teams
- I don't know what the structure is; management changes it to a daily basis

Q53 When assigned as a project leader, your project manager obtains resources by:
- "Fighting" for the best people available
- Negotiating with line managers for the best people available
- Negotiating for deliverable rather than people
- Using senior management to help get the appropriate people
- Taking whatever he or she can get, no questions asked

Q54 Your line managers:
- Accept total accountability for the work in their line
- Ask the project managers to accept total accountability
- Try to share accountability with the project managers
- Hold the assigned employees accountable
- Don't know the meaning of the word accountability ; it is not part of your company's vocabulary

Q55 In the culture within your company, the person most likely to be held accountable for the ultimate technical integrity of the final deliverable is/are:
- The assigned employees
- The project manager
- The line manager
- The project sponsor
- The whole team

Q56 In your company, the project manager's authority comes from:
- Within himself/herself, whatever he/she can get away with
- The immediate superior to the project manager
- Documented job descriptions
- Informally through the project sponsor in the form of a project charter or appointment letter

Q57 After project go-head, your project sponsors tend to:
- Become invisible, even when needed
- Micromanage
- Expect summary-level briefings once a week
- Expect summary-level briefings once every two weeks
- Get involved only when a critical problem occurs or at the request of the project manager or line managers

Q58 What percentage of your projects have sponsors who are at the director level or above?
- 0 - 10 %
- 10 - 25%
- 25 - 50%
- 50 - 75%
- More than 75%

Q59 Your company offers approximately how many different internal training courses for the employees (courses that can be regarded as project-related)?
- Less than 5
- 6 - 10
- 11 - 20
- 21 - 30
- More than 30

Q60 With regards to your previous answer, what percentage of the courses are more behavioral than quantitative?
- Less than 10%
- 10 - 25 %
- 25 - 50%
- 50 - 75%
- More than 75%

Q61 Your company believes that:
- Project management is a part-time job
- Project management is a profession
- Project management is a profession and employees should become certified as project management professionals but at their own expense
- Project management is a profession and the company pays for employees to become certified as project management professionals
- There are no project managers in your company

Q62 Your company believes that training should be:
- Performed at the request of employees
- Performed to satisfy a short-term need
- Performed to satisfy both long- and short-term needs
- Should be performed only if there exists a return on investment on training dollars

Q63 Your company believes that the content of training courses is best determined by the:
- Instructor
- Human Resources Department
- Management
- Employees who will receive the training
- Customization after an audit of the employees and managers

Q64 What percentage of the training courses in project management contain documented lessons learned case studies from other projects within your company?
- None
- Less than 10%
- 10-25%
- 25-50%
- More than 50%

Q65 What percentage of the executives in your functional (not corporate) organization have attended training programs or executives briefing specifically designed to show executives what they can do to help project management mature?
- None! The executives know everything
- Less than 25%
- 25-50%
- 50-75%
- More than 75%

Q66 In your company, employees are promoted to management because:
- They are technical experts
- They demonstrate the administrative skills of a professional manager
- They know how to make sound business decisions
- They are at the top of their pay grade
- There is no place else to put them

Q67 A report must written and presented to the customer. Neglecting the cost to accumulate the information, the approximate cost per page for a typical report is:
- You have no idea
- $100-$200 per page
- $200-$500 per page
- Greater than $500 per page
- Free; exempt employees in our company prepare the reports at home on their own time

Q68 Which of the following best describes the culture within your organization?
- Informal project management based upon trust, communication, and cooperation
- Formality based upon policies and procedures for everything
- Project management thrives on formal authority relationships
- Executives meddling, which forces an overabundance of documentation
- Nobody trusts the decisions of our project managers

Q69 What percentage of the project manager's time each week is spent preparing reports?
- 5-10%
- 10-20%
- 20-40%
- 40-60%
- Greater than 2 hours

Q70 During project planning, most of your activities are accomplished using:
- Policies
- Procedures
- Guidelines
- Checklists
- None of the above

Q71 The typical time duration for a project status review meeting with senior management is:
- Less than 30 minutes
- 30-60 minutes
- 60-90 minutes
- 90 minutes - 2 hours
- Greater than 2 hours

Q72 Your customers mandate that you manage your projects:
- ❍ Informally
- ❍ Formally, but without customer meddling
- ❍ Formally, but with customer meddling
- ❍ It is your choice as long as the deliverable are met

Q73 Your company believes that less competent employees:
- ❍ Should never be assigned to teams
- ❍ Once assigned to a team, are the responsibility of the project management for supervision
- ❍ Once assigned to a team, are the responsibility of their line manager for supervision
- ❍ Can be effective is assigned to the right team
- ❍ Should be promoted into management

Q74 Employees who are assigned to a project team (either full-time or part-time) have a performance evaluation conducted by:
- ❍ Their line manager only
- ❍ Their project manager only
- ❍ Both the project and line managers
- ❍ Both the project and line managers, together with a review by the sponsor

Q75 Which pair of skills is probably the most important for project managers of your company into the twenty-first century?
- ❍ Technical knowledge and leadership
- ❍ Risk management and knowledge of business
- ❍ Integration skills and risk management
- ❍ Integration skills and knowledge of business
- ❍ Communication skills and technical understanding

Q76 In your organization, the people assigned as project leaders are usually:
- ❍ First-line managers
- ❍ First- or second-line managers
- ❍ Any level management
- ❍ Usually non-management employees
- ❍ Anyone in the company

Q77 The project managers in your organization have undergone at least some degree of training in:
- ❍ Feasibility studies
- ❍ Cost-benefit analyses
- ❍ Both Feasibility studies and Cost-benefit analyses
- ❍ Your project managers are brought on board after project approval /award

Q78 Your project managers are encouraged to:
- ❍ Take risks
- ❍ Take risks upon approval by senior management
- ❍ Take risks upon approval of project sponsors
- ❍ Avoid risks

Q79 Consider the following statement: Your project managers have a sincere interest in what happens to each team member after the project scheduled to be completed.
- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

THANK YOU.