International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:6, No:12, 2012

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

Whee Yen Wong, Kim Yeow Tshai, and Chan Wai Lee

***Abstract*—**There are various approaches to implement quality improvements. Organizations aim for a management standard which is capable of providing customers with quality assurance on their product/service via continuous process improvement. Carefully planned steps are necessary to ensure the right quality improvement methodology (QIM) and business operations are consistent, reliable and truly meet the customers' needs. This paper traces the evolution of QIM in Malaysia's Information Technology (IT) industry in the past, current and future; and highlights some of the thought of researchers who 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. This paper aims to provide a general overview of different types of QIMs available for IT businesses in maximizing business advantages, enhancing product quality, improving process routines and increasing performance earnings.

***Keywords*—**Evolution, Integrating and Aligning, Malaysia's Quality Improvement Methodology, Six Sigma Data Quality Management.

I. Introduction

IMPLEMENTING project management and quality management programs introduce changes into the work environment. This means moving people from old methods, structures and procedures into new ones. This involves learning new skills and roles. Times have changed; organizations that do not follow best practices are at a competitive disadvantage to those who apply a structured process to each project. The future looks bright for those organizations that are prepared to pay attention to these trends. Companies are looking for more "Problem Solvers" inside the workplace and encouraging quality managers, project managers and others to use their skills, knowledge and expertise to solve problems permanently.

Whee Yen Wong is a full-time Phd student with the Mechanical, Manufacturing and Materials Engineering Department, The University of Nottingham, Jalan Broga, 43500 Semenyih, Selangor Darul Ehsan, Malaysia, on leave from the University of Tunku Abdul Rahman, UTAR Complex, Jalan Genting Kelang, 53300, Setapak, Kuala Lumpur, Malaysia (e-mail: keyx1wwn@nottingham.edu.my; wongwy@utar.edu.my).

Kim Yeow Tshai is with the Mechanical, Manufacturing and Materials Engineering Department, The University of Nottingham, Jalan Broga, 43500 Semenyih, Selangor Darul Ehsan, Malaysia (e-mail: Kim-Yeow.Tshai@nottingham.edu.my).

Chan Wai Lee is with the Mechanical, Manufacturing and Materials Engineering Department, The University of Nottingham, Jalan Broga, 43500 Semenyih, Selangor Darul Ehsan, Malaysia (e-mail: Chan-Wai.Lee@nottingham.edu.my).

II. Overview: Information Technology Sector in Malaysia

A. Introduction

Malaysia is a developing nation and its fast-developing economy makes it crucial for organizations to learn as much and as quickly as possible especially in the area of QIMs in the field of IT [1]. The IT sector in Malaysia is a booming industry and Malaysia strives to be part of the "Information Age" in the new millennium by transforming itself towards a knowledge-based economy. In order to provide the catalyst for the expansion of IT and multimedia industries in Malaysia, the Multimedia Super Corridor (MSC) was launched as part of government initiatives with the aim to revolutionize how the world does business [2]. To-date, MSC Malaysia has accomplished tremendous achievements 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].

By recognizing that IT and multimedia will be the future enabling tool to increase efficiency, productivity and competitiveness of the economy, various improvement initiatives were taken to promote the use and development of IT in Malaysia. ICT plays a key role in the 10th Malaysia Plan (RMKe-10, 2011-2015). The contribution of the ICT industry to Gross Domestic Product (GDP) is targeted to increase to 10.2% by 2015 [4] as compared to 9.8% of the nation's total GDP in year 2009 [5]. Greater use of ICT will not only support the growth of the sector but also boost productivity and raise the nation's overall competitiveness.

In the effort to strengthen organizations' performance in term of its quality management, its customers and its stakeholders satisfaction; most IT organizations attempt to adopt different QIMs. However, only a small percentage of these organizations manage to succeed completely, and majority eventually abandons the initiative [6], [7]. Though Malaysia was considered a middle-ranking developing nation in the implementation of quality management [1], it is estimated that more than 900 improvement initiatives can be used to improve an organization's performance [8]. It is well-known that every company realizes the importance of implementing quality strategies [9].

B. Online Survey

An online questionnaire was conducted with a vast group of IT organizations in Malaysia to capture viewpoints of local

SMEs on the evolution of different QIMs adoption among the IT organizations in the past, current and for the future. The online survey used in this study consisted of two parts: the background of the company and the QIM adoption pattern.

A total of 100 online survey invitations were sent to IT companies of different IT business areas covering software house, hardware manufacturer and retailer, software distributor, IT consulting services, software distributor and others. The response rate from these invited companies was 37 percent (37 companies). The majority of the respondents were Project Manager (27%), Software Engineer/Developer (24%), System/Business Analyst (22%), IT Consultants (8%) etc.

The purpose of this study was to understand the evolution of different QIM adoption among the IT organizations in the past, current and for the future. QIM plays an important role in quality management system. There are many types of QIMs being adopted and implemented in Malaysia IT organizations. These QIMs have been discussed and reviewed by various researchers, and the findings from these reviewed papers [10]-[21] presents the most widely used QIMs for today's problem-solving and quality improvement purposes. They are:

- Capability Maturity Model (CMM/CMM-I)
- International Standard Organization (ISO 9000)
- Business Process Reengineering (BPR)
- Software Process Improvement and Capability Determination (SPICE)
- Balance Scorecard
- BOOTSTRAP
- Information Technology Infrastructure Library (ITIL)
- Personal Software Process (PSP)
- Lean-Sigma
- Six Sigma

C. Analysis of Survey Data – Overview

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 the IT companies. Six Sigma and Lean-Sigma have appeared to be the *future* rising stars gaining much attention amongst the IT companies as a means of continuous quality improvement compared with ITIL and ISO for day-to-day quality management. Fig. 1 and Fig. 2 outline the adoption and evolution of QIMs of Malaysia's IT companies in the past, current and in the future trend.

D. Analysis of Survey Data – Malaysia's QIM in the Past

For the past three decades, companies in Malaysia have been carried out different QIMs for IT projects as part of the continuous improvement for day-to-day operational activities [6]. ISO was first introduced in Malaysia in the late 1980s [1]. Ever since then, there are significant developments, adoption and certification of ISO amongst the Malaysian IT companies [1], [22]. In mid 1996, in conjunction with the announcement of the Prime Minister Tun Datuk Dr. Mahathir Mohamed regarding the seriousness and importance of the government placement into the efficiency and effectiveness of operation management of the public services and government bodies, the central government has since issued circulars encouraging departments and agencies to seek ISO 9000 certification in the near future [1].

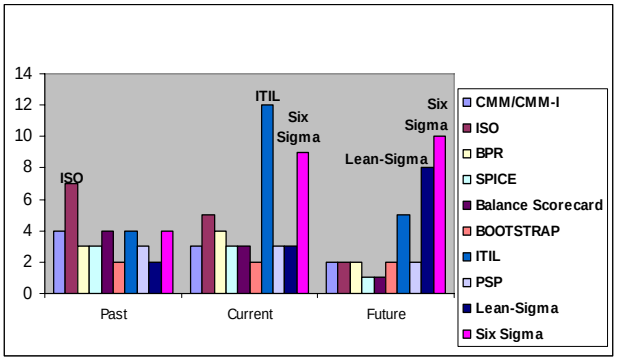

Fig. 1 The Adoption of QIMs in Malaysia's IT Industry

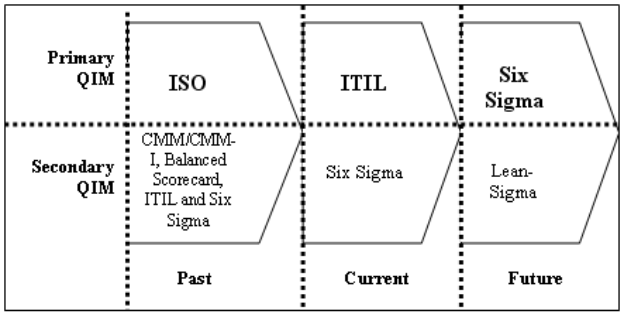

Fig. 2 The Evolution of QIMs in Malaysia's IT Industry

The Malaysian government and business organizations view ISO as one of the tools that can improve efficiency and effectiveness of both the public and private sectors; IT and non-IT firms. With parallel support from Malaysian's government, strong commitment and dedication from the top management of IT and non-IT companies, there are about 6,800 Malaysian companies registered with ISO 9001:2000 certifications as at 31st December 2007 [1]. This can be shown through results tabulated in Fig. 1 where ISO gained much popularity amongst IT companies in the past.

The purposes of the ISO 9000 standards were to facilitate the multinational exchange of products and services by providing a clear set of quality system requirements [23]. The ISO 9000 standards provide a baseline against which an organization's quality system can be judged. This generic and systematic nature of the standards allows interested companies to determine the specifics of how the standards can be applied to their organization.

Most IT companies choose ISO 9000-1 as a basis for certification to satisfy customers' requirements, a general

consideration which has greater weight than the internal desire to improve quality [8], [10], [24]. ISO 9001 standard defines a process as "a set of interrelated resources and activities which transform inputs into outputs." In particular, ISO 9001 is a standard that provides requirements (i.e. what needs to be done right) on key factors affecting the outcome of any IT products, services or process developments such as cost, time, task and quality. In short, ISO is the application of standards following a specific domain of guidelines which requires continuous improvements due to changes of internal (employee, company direction, culture etc) and external (technology, respective country IT trend etc) factors. It serves as "guidance" and a compliant set of processes to be followed by all team members. Many IT companies (i.e. software houses and software suppliers) try to demonstrate their achievement in software process improvements by obtaining an ISO 9001 certification [10] and uses ISO 9000-1 as a kick-start bases for self-improvement or internal-assessment for IT project quality management standard.

E. Analysis of Survey Data – The Current State of Malaysia's QIM

The Information Technology Infrastructure Library (ITIL) is a set of best-practices for IT service management (ITSM) that focuses on aligning IT services with the needs of the business. The purpose of ITIL is to lace responsibility rather than to create an organization structure and to provide a comprehensive and cohesive set of templates and best practices for core IT operational processes. ITIL allows organizations to establish a baseline from which it can plan, implement, and measure; at the same time demonstrate compliance and measure improvement [25], [26].

ITIL does not require a completely new approach; it will form a framework in which existing ideas will be placed in order to create a strategic advantage in terms of service management. Therefore, by establishing the existing links between processes, their roles and activities, any faults in the linkage can be removed. This clearly explains and supports the drastic switch of ISO in the past to ITIL adoption in these recent years in IT companies. The main reason behind this switch is the similarity between ISO and ITIL.

ITIL and ISO are complimentary and mutually supportive and ISO could be an enabler to launch ITIL. The set of predefined-standards in the ISO quality manual can be easily fit into ITIL which consist of a set of statements that explain the 'best practices' of successful IT related processes [27]. Therefore, an organization that implements ISO is generally likely to implement ITIL more easily as the foundation and basis of the "operational bible" is ready for implementation and adoption with little changes necessary. Most importantly, ITIL is a framework and does not require a license to practice and is independent of any commercial solution or platform [25]. Therefore, efforts to implement and adopt ITIL at different stages of the project life cycle are more viable and economical. Furthermore, ITIL also provides a common language for IT operational processes that enable better tracking of service deliveries and root-cause analyses of chronic service delivery problems [28].

Another reason for the diminishing demand and increasing competition for ISO was the amount of money, time and paperwork required for ISO registration. The average time needed to implement an IS0 9000 quality system is 1.5 years [10]. Although there is supporting argument that a software house which has already installed a quality system before starting the IS0 9000 initiative only needs approximately one year to adapt it to the requirements of IS0 9000, a company designs a quality system "from scratch" would take at least 2 years [10]. Furthermore, ISO 9001 is not in any way an indication that products produced using its certified systems are any good or better than competitors'. Besides, ISO 9000 certification is seen to be assumption based to impress customers, but by itself certification does not necessarily correlate with improved quality [24]. It could be a product/service provider that conforms to all the ISO criteria but deliver product/service which does not meet customer needs nor improve organizational performance [24].

The general misconception of ISO has encouraged ITIL to become a de-facto standard and the most widely used and accepted approach in defining processes for IT service-oriented organizations over the past 24 years [29]. It informs IT management what needs to be done and how it will get done from the process perspective [26]. At present, ITIL is the most widely accepted approach to IT Service Management in the world [30]. The best practices from ITIL's framework can be used to assist organizations' fine-tuning of processes as their needs and technology evolve [25]. This can be clearly proven when organizations benefit 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 return on investment (ROI) [25]. At the same time, there is a positive impact of higher productivity from both business and IT staff.

F. Analysis of Survey Data – The Malaysia's QIM in the Future

IT Service/Product/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 scales/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 [31]. Fig. 1 and Fig. 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) [20], [32].

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 I. 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 I
SIX SIGMA AWARENESS IN MALAYSIA'S IT INDUSTRY

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%

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 aspects. It especially demands changes of the external and internal IT environment.

III. THE SHIFT OF IT QUALITY IMPROVEMENT METHODOLOGY SELECTION

Industrial, manufacturing and service organizations are interested in improving their products, services and processes by adopting and implementing a QIM which demonstrate a total solution from operational and procedural methods to customers' feedback. This is because the competitive and stressed environment leaves little room for error(s) in data quality and customer satisfaction. We must deliver and develop products and services at the ideal target (or acceptable level) demanded by the customers. Quality has marked a long tradition in all industries. Quality Management (QM) does not only aim to assure 'good quality' by its general definition, but more explicitly to ensure the products/services of an organization are consistent and in accordance to specifications and predefined guidelines.

Advanced companies today are in search of business excellence to meet the challenges of globalization in all market segments. 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. This traditional method of QIM selection has a tremendous impact on the traditional profession of quality managers in individual organizations where the QM lifecycle is comfortably stagnant in the phase of quality assurance without business directive proceeding to the next level. Besides, the traditional method of QIM lack 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 [33].

QA refers to the planned and systematic activities implemented in a quality system so that the quality requirements for any products/services will be fulfilled [34]. It is the systematic measurement, comparing with a standard, monitoring of the processes and an associated operational loop (two-ways) that confers error prevention. QA is indeed in contrast when compared to QC which is focused on process outputs. QC is an observation technique and activity used to fulfill requirements for quality [34]. In the field of IT, QC emphasizes testing of products to uncover/reduce defects/variations and reporting to the project team who make the decision to allow or deny product release; whereas QA attempts to improve and stabilize production (normally associated with processes) to avoid, or at least minimize, issues which led to the defect(s)/variation(s) in the first place.

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". However, the aspect of *evaluation criteria* of these predefined-rules has been overlooked and neglected which placed the traditional quality improvement in position for a good start for quality management but struggled to promise on-going revolutionary results. Hence, 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 strategizing the

businesses with the ability of evaluating business operation.

Due to the mis-conceptuals and mis-interpretations between QA and QC, there is a rising pressure faced by QM team to opt or 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 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 [35]. 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 [35].

IV. The Evolution of Quality Improvement Methodology Selection

Lately, practitioners are integrating two or more QIM into a more powerful and effective hybrid QIM, addressing many of the weaknesses and retaining most of the strengths of each strategy [35]-[37]. 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 is generated by the organization [35]. Furthermore, this new approach of integrating and and/or aligning 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.

A comprehensive literature reviews highlighted the degree of alignment and integration in various combinations of QIM as shown in Fig. 3. 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. Fig. 3 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. 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 of 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. 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.

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/aligning with other QIMs which enforces "continuous improvement".

Below 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/services:

1) Antony [38] 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 [39].
2) Seow [32] 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 [40].

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 [40].
4) Byrne [41] 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 [41].

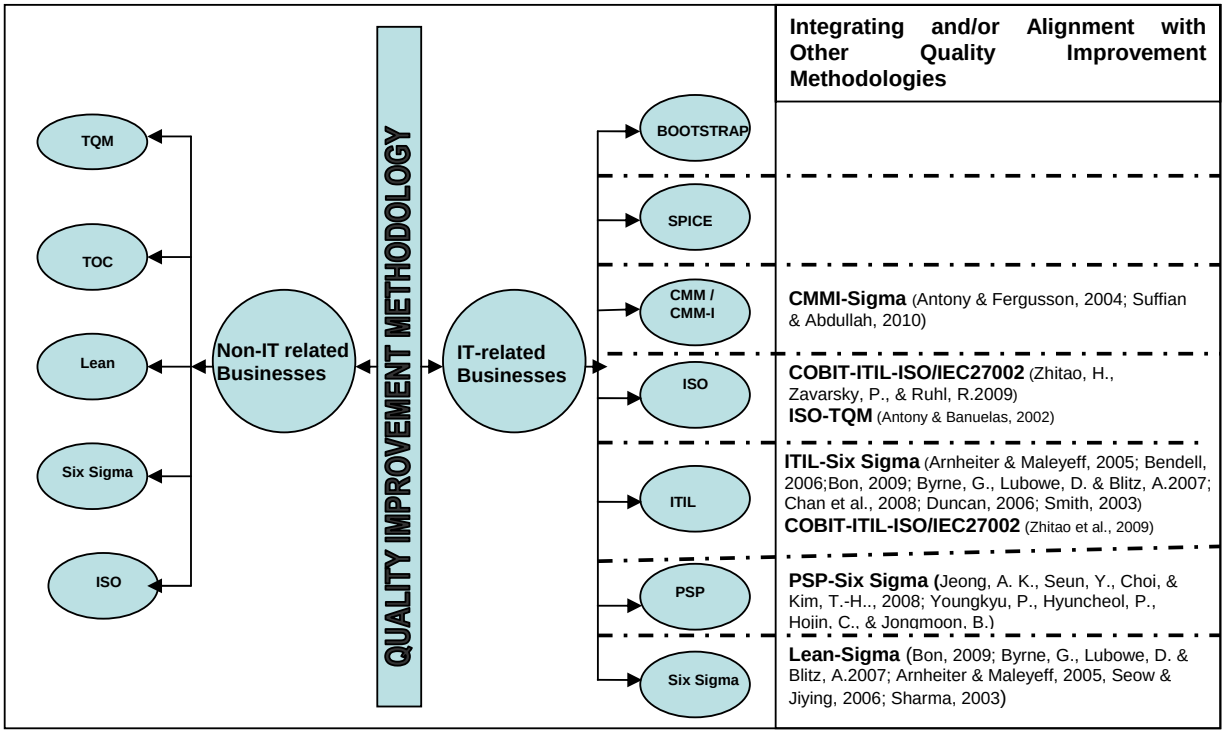

Fig. 3 The Combination Matrix Mapping of QIMs

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 [19], [25], [42], [43]. 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 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 reinforces collaboration across the enterprise [25].
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 [25].
7) Even PSP has been likened to applying Six Sigma toward Software Development [44]. 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 [44]. 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 [45].

The reason why there is a need to create awareness and to explore the potentials alignment and/or integration of existing

QIM with other QIM(s) 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.

V. The New Paradigm Shift of QIM Selection

At the dawn of the new millennium, society is moving towards the information age. Phenomenal growth of the IT industry due to demand of engineering, information technology and management professionals have shifted the whole paradigm and philosophy of quality management system is more focusing in quality control and quality improvement. Many IT companies are now being assessed according to standards that have brought substantial profit to the companies, and drive them to improve the quality of software products. Many trendy quality initiatives promised revolutionary results from using different and latest/popular rigorous standards often fade before they can turn the effort into measurable benefits and profits because they require much time and money to maintain.

These days, there is an emergent shift paradigm of adopting Six Sigma as the upcoming QIM because *Six Sigma* is often considered the "*modern form of quality management*" [46]. Empirical evidence showed that traditional methods of quality management (e.g. ISO, ITIL, PSP, CMM/CMM-I, SPICE, BOOTSTRAP, Benchmarking, Balance Scorecard etc) are displaced directly in the line of business operation processes [46]. Is now the right time for the IT industry to consider taking a new facelift of adopting Six Sigma as the quality improvement initiative? The answer is "Yes". Although the above statement of Six Sigma is not commonly or universally understood and accepted by majority of the IT professional, there is evidence to suggest the benefits of integrating or aligning various traditional software process initiatives (SPI) with Six Sigma. The reason for the disagreement of adopting and implementing Six Sigma in IT is due to the common myth that Six Sigma is only for large organizations or manufacturing firms. This is not true. Six Sigma goes beyond manufacturing. 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.

The full potential of Six Sigma has not been realized so far since many competent and highly potential SMEs are partially or informally or have still not implemented Six Sigma initiatives. These enterprises have all the necessary foundation (e.g. resources, budget, platform) to implement such programs, but are often wary and sceptical of the final certification, as they believe that it is meant only for large organizations. These companies often do not realize that Six Sigma delivers the same benefits to both large as well as small business enterprises. The only difference may be in different scales of implementation.

TABLE II
The Combinations Matrix of Different QIMs

Quality Improvement Methodology	TQM	TOC	Lean	BBOT-STRAP	SPICE	CMM / CMM-I	ISO	ITIL	PSP	Six Sigma	CORBIT
TQM							[47]				
TOC											
LEAN										[35], [40], [41], [43], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57]	
BOOTSTRAP											
SPICE											
CMM / CMM-I								[58]		[39]	
ISO											[59]
ITIL										[41], [48], [49]	
PSP										[44]	
SIX SIGMA											
CORBIT											

TABLE II outlines 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 and/or aligned 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 [40]. 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 [40].

Six Sigma may appear similar to other quality management tools such as TQM or Lean or others, but in reality, it is quite different. The other quality management programs often reach a stage after which no further quality improvements can be made. Six Sigma, on the other hand, is different as it focuses on taking quality improvement processes to the next level. This means that Six Sigma has the potential to outlast other quality management programs in the future.

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/products are reduced; the chances of faulty, 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.

VI. What is so Special about Six Sigma?

Customers need consistent, reliable and predictable processes that deliver or exceed the best-in-class level of quality. This is what the Six Sigma process strives to achieve [60]. 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 [25], [40]. This statistically based problem-solving methodology of Six Sigma delivers data to drive solutions, delivering dramatic bottom-line results [35]. 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 [35], [40]. Because Six Sigma relies on probability, statistical measurement techniques, and systematic data gathering, it is a powerful decision-making and analytical tool [40]. Furthermore, Six Sigma combines the variability of reduction tools and techniques with other QIM to generate savings to the bottom-line of an organization [35].

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 [35]. 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 approach for quality improvement based on defined metrics in manufacturing, service, or financial processes [61].

Implementing Six Sigma alone has created many success stories and dramatic results in various industries such as banking [62], healthcare [63], [64], leisure service quality [65], internet service provider [66], retailing [67] 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 or align 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 [68].

VII. The Evolution of 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 [61].

In particular, Six Sigma can be implemented into the era of product/service/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 we think about Six Sigma, i.e. Reducing Process/Product/Service Variation, Simplifying Product/Service/Process Design, Look at your offering from customers' perspective [69]. 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/or 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 [69].

Six Sigma's strength lies in the combination of all the elements and the way they support each other [68]. Today, Six

Sigma is seen as a business excellence model for concrete areas and as a methodology in order to reach business goals [13]. The popularity of the company's products or service will enhance, only if a proper quality system is in place. Therefore, companies require focus and direction of its resources, money and time on a quality management methodology which drives operational excellence and perfection, for now and in the future.

VIII. Conclusion

Over the last twenty years, Six Sigma has been successfully implemented in many industries, from large manufacturing to small businesses, from financial services, insurance industry, education institutions to healthcare systems; from engineering and construction sector, airline systems and services, consultation services to retail industry. 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.

Quality lives in the hands of responsible people who are empathetic of the advantages of Six Sigma and not with those whose attitudes compel them to decry Six Sigma just because it shares commonality with earlier statistical quality tools. 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, whose tools was created and perfected over nearly a century, has the potential to transform the business environment and customers, which 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.

In conclusion, Six Sigma implementation in Malaysia's IT industry has been theoretically justified with literature reviews and practically proven 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 aligning/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.

References

[1] R. A. Wahid, "Beyond Certification: The Maintenance of ISO 9000 in Malaysian Service Organizations." vol. Doctor of Philosophy: The University of Waikato, 2010, p. 414.

[2] www.msc.com.my, "MSC Malaysia Information Technology Service Management (CDP ITSM) Program." vol. 2011.

[3] "MSC Malaysia Information Technology Service Management (CDP ITSM) Programme Guideline," C. D. D. (MDec), Ed. Cyberjaya, pp. 1-9.

[4] A. Kumar, "ICT to play bedrock role in 10th Malaysia Plan," Computerworld Malaysia, 2010.

[5] "ICT is key enabler in 10th Plan blueprint," in *Star Publications (M) Bhd*: TechCentral, 2010.

[6] N. Mohd Hairul Nizam Md, R. Ahmad, and N. H. Hassan, "Resistance factors in the implementation of software process improvement project," in *Information Technology, ITSim. International Symposium*, 2008, pp. 1-10.

[7] Josiane Brietzke and A. Rabelo, "Resistance Factors in Software Processes Improvement," *CLEI Electronic Journal,* vol. 9, June 2006.

[8] M. Mohammad, R. Mann, N. Grigg, and J. P. Wagner, "The right improvement initiative for the right situation: A contextual and systems approach," *Computers and Industrial Engineering (CIE), 40th International Conference*, pp. 1-6, 25-28 2010.

[9] A. Sergej and S. Liudmila, "Striving for Business Excellence in Belarus − Tendencies of quality management in IT industry," in *Baltic Business School*: University of Kalmar. Sweden, 2006, p. 103.

[10] D. Stelzer, W. Mellis, and G. Herzwurm, "Software process improvement via ISO 9000? Results of two surveys among European software houses," in *System Sciences, 1996., Proceedings of the Twenty-Ninth Hawaii International Conference on*, 1996, pp. 703-712 vol.1.

[11] A. C. Tonini, M. de Mesquita Spinola, and F. J. Barbin Laurindo, "Six Sigma and Software Development Process: DMAIC Improvements," in *Technology Management for the Global Future, PICMET*, 2006, pp. 2815-2823.

[12] J. D. Jens and D.-P. Su Mi, "Lean production, six sigma quality, TQM and company culture," *The TQM Magazine,* vol. 18, pp. 263 - 281, 2006.

[13] R. Andersson, H. Eriksson, and H. Torstensson, "Similarities and differences between TQM, six sigma and lean," in *The TQM Magazine*. vol. 18, 2006, pp. 282 - 296.

[14] T. K. Varkoi and T. K. Makinen, "Case study of CMM and SPICE comparison in software process assessment," in *Engineering and Technology Management, Pioneering New Technologies: Management Issues and Challenges in the Third Millennium.(IEMC) Proceedings. International Conference on*, 1998, pp. 477-482.

[15] R. C. Bamford and W. J. Deibler, II, "Standards-comparing, contrasting ISO 9001 and the SEI capability maturity model," *Computer,* vol. 26, pp. 68-70, 1993.

[16] R. F. de Sousa Pereira and M. M. da Silva, "A Maturity Model for Implementing ITIL v3," in *Services (SERVICES-1), 6th World Congress on*, 2010, pp. 399-406.

[17] A. M. J. Hass, J. Johansen, and J. Pries-Heje, "Does ISO 9001 increase software development maturity?," in *24th ,Euromicro Conference Proceedings.* 1998, pp. 860-866 vol.2.

[18] D. Nave, "How to Compare Six Sigma, Lean and the Theory of Constraints," in *Quality Progress.* vol. March, 2002.

[19] T. Bendell, "A review and comparison of six sigma and the lean organisations," *The TQM Magazine,* vol. 18, pp. 255 - 262, 2006.

[20] P. Catherwood, "What's different about Six Sigma?," in *Manufacturing Engineer*, 2002, pp. 186-189.

[21] W. Y. Wong, C. W. Lee, and K. Y. Tshai, "A Roadmap to Quality Improvement Methodology Selection," in *3rd IEEE International Conference of Emergency Management and Management Science, ICEMMS* Beijing, p. 310-315, 2012.

[22] A. T. Ali, "Implementing international quality system standards: The Malaysian experience," *Asia Pacific Journal of Quality Management,* vol. 3, p. 28, 1994.

[23] D. S. Chang and L. K. Lo, "Measuring the relative efficiency of a firm's ability to achieve organizational benefits after ISO Certification," *Total Quality Management,* vol. 16, pp. 57-69, 2005.

[24] E. Naveh and A. A. Marcus, "When does the ISO 9000 quality assurance standard lead to performance improvement? Assimilation and going beyond," *Engineering Management, IEEE Transactions on,* vol. 51, pp. 352-363, 2004.

[25] P. Chan, S. Durant, V. Gall, and M. Raisinghani, "Aligning Six Sigma and ITIL: Implications For IT Service Management," *CONF-IRM Proceedings,* vol. 7, 2008.

[26] R. L. Edgeman, D. Bigio, and T. Ferleman, "Six Sigma and Business Excellence: Strategic and Tactical Examination of IT Service Level Management at the Office of the Chief Technology Officer of Washington, DC," *Quality and Reliability Engineering International,* vol. 21, pp. 257-273, 2005.

[27] A. Hochstein, R. Zarnekow, and W. Brenner, "ITIL as Common Practice Reference Model for IT Service Management: Formal Assessment and Implications for Practice," in *Proceedings of the IEEE International Conference*, 2005, pp. 704 – 710.
[28] C. V. Brown, D. W. DeHayes, J. A. Hoffer, E. W. Martin, and W. C. Perkins, *Managing Information Technology*, 7th Edition ed. New Jersey: Prentice Hall, 2012.
[29] Z. Shaohua, W. Peng, D. Zhigang, and Z. Yuwei, "Organization ITIL Process Integration Based on Web Services," in *Software Engineering, 2009. WCSE '09. WRI World Congress on*, 2009, pp. 412-416.
[30] H. B. Esmaili, H. Gardesh, and S. S. Sikari, "Validating ITIL maturity to strategic business-IT alignment," *2nd International Conference* in *Computer Technology and Development (ICCTD)*, 2010, pp. 556-561.
[31] http://www.businessballs.com/sixsigma.htm. vol. 2011.
[32] C. Seow and L. Jiying, "Innovation in Maintenance Strategy through Six Sigma: Insights of a Malaysian SME," in *Management of Innovation and Technology, 2006 IEEE International Conference on*, 2006, pp. 793-797.
[33] M. Kaufman and R. Dorin, "Adopting a Lifecycle Approach to Software Quality Management," Newton: Hurwitz & Associates, 2007.
[34] www.asq.org/learn-about-quality/, "Quality Assurance and Quality Control." vol. 2012.
[35] M. Kumar, J. Antony, R. K. Singh, M. K. Tiwari, and D. Perry, "Implementing the Lean Sigma framework in an Indian SME: a case study," *Production Planning & Control,* vol. 17, pp. 407-423, 2006.
[36] S. Sivakumar and K. Muthusamy, "Critical success factors in Six Sigma implementation; A case study of MNCs in Malaysia," in *IEEE International Conference on Quality and Reliability, ICQR*, 2011, pp. 536-540.
[37] A. A. Latif, M. M. Din, and R. Ismail, "Challenges in Adopting and Integrating ITIL and CMMi in ICT Division of a Public Utility Company," in *Second International Conference on Engineering and Applications (ICCEA)*, 2010, pp. 81-86.
[38] J. Antony and C. Fergusson, "Six Sigma in the software industry: results from a pilot study," *Managerial Auditing Journal,* vol. 19, pp. 1025-1032, 2004.
[39] M. D. M. Suffian and M. R. Abdullah, "Establishing a defect prediction model using a combination of product metrics as predictors via Six Sigma methodology," in *Information Technology (ITSim), International Symposium in*, 2010, pp. 1087-1092.
[40] U. Sharma, "Implementing Lean principles with the Six Sigma advantage: How a battery company realized significant improvements," *Journal of Organizational Excellence,* vol. 22, pp. 43-52, 2003.
[41] G. Byrne, D. Lubowe, and A. Blitz, "Using a Lean Six Sigma approach to drive innovation," in *Strategy & Leadership*. vol. 35, E. G. P. Limited, Ed., 2007, pp. 5-10.
[42] M. Duncan, "Six Sigma methodology: reducing defects in business processes," *Filtration & Separation,* vol. 43, pp. 34-36, 2006/2.
[43] B. Smith, "Lean and Six Sigma- A One-Two Punch," in *Quality Progress*. vol. April 2003: American Society for Quality, 2003, pp. 37-41.
[44] A. K. Jeong, Y. Seun, Choi, and T.-H. Kim, "Management Environment for Software Process Improvement," in *Computer Science and its Applications, 2008. CSA '08. International Symposium on*, 2008, pp. 292-296.
[45] P. Youngkyu, P. Hyuncheol, C. Hojin, and B. Jongmoon, "A Study on the Application of Six Sigma Tools to PSP/TSP for Process Improvement," in *Computer and Information Science, and 1st IEEE/ACIS International Workshop on Component-Based Software Engineering, Software Architecture and Reuse. ICIS-COMSAR 2006. 5th IEEE/ACIS International Conference on*, 2006, pp. 174-179.
[46] T. Pfeifer, W. Reissiger, and C. Canales, "Integrating six sigma with quality management systems," in *TQM Magazine*. vol. 16, 2004, pp. 241-249.
[47] J. Antony and R. Banuelas, "Key ingredients for the effective implementation of Six Sigma program," *Measuring Business Excellence,* pp. 20-27, 2002.
[48] A. T. R. Bon, "Quality measurement in lean manufacturing," in *Instrumentation, Communications, Information Technology, and Biomedical Engineering (ICICI-BME)*, 2009, pp. 1-7, 23-25
[49] E. D. Arnheiter and J. Maleyeff, "The integration of lean management and Six Sigma," in *The TQM Magazine*. vol. 17, 2005, pp. 5-18.
[50] d. K. Henk, P. S. V. John, v. d. H. Jaap, B. Soren, and J. M. M. D. Ronald, "Lean Six Sigma in Healthcare," *Journal for Healthcare Quality,* vol. 28, pp. 4-11, 2006.
[51] D. Näslund, "Lean, six sigma and lean sigma: fads or real process improvement methods?," *Business Process Management Journal,* vol. 14, pp. 269-287, 2008.
[52] J. Antony, J. L. Escamilla, and P. Caine, "Lean Sigma [production and supply chain management]," *Manufacturing Engineer,* vol. 82, pp. 40-42, 2003.
[53] M. L. George, "Lean Six Sigma for Service," US: McGraw-Hill, 2003.
[54] B. Hurley, T. Taylor, J. Levett, C. Huber, and E. Hahn, "Implementation of six sigma and lean methodology into the anticoagulation management process," *Journal of Thrombosis and Thrombolysis,* vol. 25, pp. 106-106, 2008.
[55] J. Langabeer, J. DelliFraine, J. Heineke, and I. Abbass, "Implementation of Lean and Six Sigma quality initiatives in hospitals: A goal theoretic perspective," *Operations Management Research,* vol. 2, pp. 13-27, 2009.
[56] A. C. Tonini, F. J. B. Laurindo, and M. de Spinola, "An Application of Six Sigma with Lean Production Practices for Identifying Common Causes of Software Process Variability," in *Management of Engineering and Technology, Portland International Center for*, 2007, pp. 2482-2490.
[57] M. F. David, J. M. Martin, and M. David, "Lean Sigma and simulation, so what's the correlation?," in *Proceedings of the 2005 Winter Simulation Conference*, 2005.
[58] A. A. Latif, M. M. Din, and R. Ismail, "Challenges in Adopting and Integrating ITIL and CMMi in ICT Division of a Public Utility Company," in *Computer Engineering and Applications (ICCEA), Second International Conference on*, 2010, pp. 81-86.
[59] H. Zhitao, P. Zavarsky, and R. Ruhl, "An Efficient Framework for IT Controls of Bill 198 (Canada Sarbanes-Oxley) Compliance by Aligning COBIT 4.1, ITIL v3 and ISO/IEC 27002," in *Computational Science and Engineering, 2009. CSE '09. International Conference on*, 2009, pp. 386-391.
[60] Q. Feng and K. C. Kapur, "New to Six Sigma? An Introduction to Six Sigma for Students and New Quality Practitioners," 2007.
[61] J. H. Gerald, J. H. William, W. H. Roger, and A. Z. Stephen, "The impact of Six Sigma improvement--A glimpse into the future of statistics," *The American Statistician,* vol. 53, pp. 208-215, 1999.
[62] U. D. Kumar, "Six Sigma — Status and Trends," in *Handbook of Performability Engineering*, 2008, pp. 225-234.
[63] L.-C. Tang, S.-W. Lam, and T.-N. Goh, "A Tasks-based Six Sigma Roadmap for Healthcare Services," in *Handbook of Performability Engineering*, 2008, pp. 1011-1024.
[64] R. Russ, D. Sperling, F. Rometsch, and P. Louis, "Applying Six Sigma in the Field of Software Engineering," in *Software Process and Product Measurement*, 2008, pp. 36-47.
[65] H. Chen, K. Chen, T. Chang, and C. Hsu, "An application of six sigma methodology to enhance leisure service quality," *Quality and Quantity*.
[66] C. Tao, S. Chen, and L. Chang, "Apply 6-sigma methodology in measuring the competition quality of satisfaction performance—an example of ISP Industry," *Quality and Quantity,* vol. 43, pp. 677-694, 2009.
[67] K. Chen, L. Ouyang, C. Hsu, and C. Wu, "The communion bridge to Six Sigma and process capability indices," *Quality and Quantity,* vol. 43, pp. 463-469, 2009.
[68] R. Caulcutt, "Why is Six Sigma so successful?," *Journal of Applied Statistics,* vol. 28, pp. 301-306, 2001.
[69] S. Puaar, "Mission Improvement," in *IEE Manufacturing Engineer*. vol. JUNE/JULY, 2003.