Special Issue on
Industrial Engineering and Management Practices
in the Caribbean

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Editor: Kit F. Pun
Head Office of the Association: Professional Centre, 11-13 Fitz Blackman Drive, P.O. Box 935,
Port of Spain, Trinidad and Tobago, West Indies
## PRESIDENTS OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF TRINIDAD AND TOBAGO

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<th>Term</th>
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<td>2000-2001</td>
<td>Imtiaz Hosein</td>
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## FOUNDATION MEMBERS OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF TRINIDAD AND TOBAGO IN 1959

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<td>Rupert V.S. Aleong</td>
<td>Founding President</td>
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<tr>
<td>Don D. Ash</td>
<td>Rudolph Balgaroo</td>
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<td>Leslie G. Dookie</td>
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<td>Peter F. Walker</td>
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### Notes
- APETT’s logo was designed by Derek Aleong.
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Editorial

I. From the Editor

A. Editor’s Note

The last published issue of the Journal appeared in October 2004 (Volume 35 Number 1), with another “Special Issue on Asset Management and Maintenance Engineering” (Volume 36 Number 1) published on-line only at the Association’s Website http://www.apett.org/pubs_journal.php in 2005. Since then, the Association has been plagued with difficulties of one kind or another in its effort to publish the Journal.

The Association has appointed a new Editor who resumed duties for the Journal in August 2007. This Special Issue on “Industrial Engineering and Management Practices in the Caribbean” is the first initiative under the new editorship. It is anticipated that an improved Journal coming off the press regularly and on schedule.

B. A New Look for the Journal

The Journal has developed a new look starting from this issue, to signify its transition to a peer-reviewed professional/scholarly journal that serves for the members of the Association and a wider fraternity of engineering at large.

Papers submitted to the Journal should be original contributions and should not be under consideration for any other publication at the same time. Each paper is to be reviewed by the Editor and, if it is judged suitable for this publication, it is then sent to two referees for double blind peer review. Based on their recommendations, the Editor then decides whether the paper should be accepted as is, revised or rejected. A new set of ‘Author guidelines’ can be referred at the back of this issue.

C. ‘The Engineer’ Magazine

On the other hand, the Association had launched a new magazine, ‘The Engineer”, in 2007. This is a practitioner-type of publication in parallel with the Journal. The Association welcomes the submission of shorter articles describing work in the field of Engineering, or material of specific interest to engineers and those working in related fields, in Trinidad and Tobago and the Caribbean region. Articles submitted to ‘The Engineer” will be subject to a lesser rigorous review process as that of the Journal.

D. Call for Papers: Two Special Issues

As part of the celebration for its 50th Anniversary, the Association is pleased to announce the publication of two Special issues for the Journal. The first one with the theme on ‘Engineering Infrastructures for Sustainable Development’ (Volume 38 Number 1) will be published in October 2009. This Special Issue will foster dialogue on relevant issues and provide a holistic examination of the current status and future trends in engineering infrastructures planning, development and management.

The second one with the theme on ‘Engineering Asset Management: Trend and Challenges’ (Volume 39 Number 1) will be targeted to publish in April 2010. Engineering asset management continues to grow in importance in both public and private sector organisations in both developed and developing countries. It is intended that contributions will provide a better understanding of trends and best practices of Engineering Assets Management that meet the diverse needs and challenges in the Caribbean Region and a wider global context.

Papers may now be submitted for both special issues. Submission deadline for the issue of ‘Engineering Infrastructures for Sustainable Development’ will be 30th April 2009, whereas for ‘Engineering Asset Management: Trend and Challenges’ be 31st October 2009. The ‘Call for Papers’ for both appears in this issue.

E. Special Issue Proposals Are Always Welcome

Proposals for special issues on topics of current interests in engineering, engineering management and related disciplines are always welcome. Please send a brief description of the concept for the issue to the Editor (KitFai.Pun@sta.uwi.edu). It will be circulated to the Journal Committee of the Association, and if the initial response is favourable, the Editor will request a specific plan and more detailed information to be used in the final decision about proceeding with the special issue.

II. About This Issue

Industrial Engineering (IE) is a people-oriented and customer-focused engineering discipline that has
been developed since the 1960s; and it is at present one of the most emerging engineering disciplines in many advanced and developing nations, like the USA, Canada, Japan, Korea, China and Columbia. The theme of this special issue is to facilitate a region-wide awareness of IE competence, the use and development of IE tools and associated management concepts and models that support companies and organisations in the Caribbean. This issue includes six research and technical articles. The relevance and usefulness of each paper are summarised below.

C.O. Benjamin, L. Monplaisir, C.K. Sankat and D. Thompson, “Industrial Engineering Education and Research: Current Issues and Future Directions for the Caribbean”, discuss the challenges and opportunities presented to Industrial Engineering educators and researchers by various contemporary issues. The authors use three case studies of ongoing initiatives in academia to assist in charting future directions in IE Education and Research in the Caribbean.

P. Pounder and D. Devonish, “Conceptualising Project Management: A Caribbean Perspective on Planning, Execution and Externalities”, discuss the institutional and policy issues and the current project management system in the Caribbean Region. Based on survey data obtained from thirty project managers in the region, this paper highlights the features of a project and key concepts in project management that need to be adapted by Regional project managers to enhance the chances of project success.

C. Drayton, “Industrial Engineering and the Application of Value Engineering in CARICOM Countries”, takes a historical perspective for the Caribbean industrialisation since the 1950s, and explores the roles of Industrial Engineering and applications of Value Engineering (VE) in the Caricom context. The paper also proposes a structured framework for incorporating IE with VE practices to create sustainable business enterprises in Caricom countries while adhering to international standards.

M.Y.R. Yiu and C.K. Sankat, “A Self-assessment Model for Evaluating Knowledge Management Performance”, investigate the key attributes of knowledge management (KM) processes and performance metrics, and propose an integrated paradigm that aligns the KM measures to attaining performance goals in organisations. Incorporated the findings of a recent study in Trinidad and Tobago, five criteria for assessing the KM practices are identified. This paper also proposes an integrated knowledge management model and devises a scoring mechanism that assists organisations in self-assessments of their performance.

K. F. Pun and P. Bhairo-Beekhoo, “A 14-Step Strategy of HACCP System Implementation in Snack Food Manufacturing”, argue that food safety is a significant part of the manufacture of any food product. The use of Hazard Analysis Critical Control Points (HACCP) is to identify preventive steps to reduce hazards. The authors use an implementation case of the HACCP system for a snack food manufacturer in Trinidad and Tobago, and advocate a 14-step implementation strategy that aligns HACCP measures for attaining safety performance goals.

N. Ugas and M.K.S. Sastry, “A Novel Control Strategy for an Ammonia Marine Loading Arm”, present the design and development of a personal computer based, novel strategy to automate the processes of control and monitoring of a manually operated Ammonia Marine Loading Arm in an industrial organisation in Trinidad and Tobago. This approach reduces the overall operating cost and improves safety standards during product loading for the company. Due to the generic design features, this control philosophy can be used with any type of marine loading arm in the ammonia manufacturing industry.

The views expressed in articles are those of the authors to whom they are credited. This does not necessarily reflect the opinions or policy of the Association.
Industrial Engineering Education and Research: Current Issues and Future Directions for the Caribbean

Colin O. Benjamin1*, Leslie Monplaisir2, Clement K. Sankat3 and Denise Thompson4

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Abstract: We discuss the challenges and opportunities presented to Industrial Engineering (IE) educators and researchers by contemporary issues related to the internet, globalisation, changing demographics, national security, lean and green manufacturing, and entrepreneurship. Case studies of ongoing initiatives in academia are provided as models to assist in charting future directions in IE Education and Research in the Caribbean by redefining programme focus, bridging the theory/practice gap, developing strategic alliances, and implementing campus-wide initiatives in Entrepreneurship. We propose the adoption of a Quality Function Deployment framework to assist IE programme stakeholders in the Caribbean - faculty, students, alumni and employers, in examining the local impact of these global issues on IE programmes and in conducting periodic review and re-examination of their mission to develop appropriate strategies and initiate programme enhancements. To be effective, IE education and training programmes in the Caribbean will require ongoing inter-university and industry-academia collaboration to ensure good resource utilisation and effective integration of teaching, research and service activities.

Keywords: Industrial Engineering, education, research, curriculum, stakeholder

1. Introduction

Industrial engineering is defined by the Institute of Industrial Engineers as being “concerned with the design, improvement, and installation of integrated systems of people, materials, information, equipment, and energy. It draws upon specialised knowledge and skills in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems” (www.iienet.org). Industrial engineers are mostly concerned with increasing productivity through the management of people, methods of business organisation, and technology. To solve organisational, production, and related problems efficiently, industrial engineers carefully study the product requirements, use mathematical methods to meet those requirements, and design manufacturing and information systems. They develop management control systems to aid in financial planning and cost analysis, and design production planning and control systems to coordinate activities and ensure product quality. They also design or improve systems for the physical distribution of goods and services, determine the most efficient plant locations, and also develop wage and salary administration systems and job evaluation programmes (www.bls.gov). In the Caribbean, IEs can apply these skill sets to make significant contributions to the region’s social and economic development by reducing waste and increasing
productivity in existing organisations and developing new, sustainable and profitable business ventures.

Since its inception as a small undergraduate programme in the early 80’s, the IE programme at the University of the West Indies (UWI) has been at the forefront of IE education and research in the Caribbean. Table 1 shows the geographical distribution of UWI IE graduates. Many have assumed leadership roles outside of the traditional engineering fields e.g. in business, banking and finance, and have made sterling contributions to the economic development of the Caribbean.

Over the years, Industrial Engineering Education and Research has moved from a focus on traditional IE techniques such as Work Measurement and Management Science to incorporate newer techniques developed to solve problems in exciting areas such as Computer Integrated Manufacturing, Lean and Green Manufacturing, Artificial Intelligence, Data Mining, Electronic Commerce, Human Computer Interaction, Information Technology, and Supply Chain Management. IE programmes in the Caribbean are needed to conduct a critical review and re-examination of their mission and develop appropriate strategies and programme enhancements to exploit current opportunities and respond to meet the important human resource development needs of stakeholders in government, business, industry and the community.

Table 1. IE Graduates of the University of the West Indies

<table>
<thead>
<tr>
<th>Territory</th>
<th>IE Graduates</th>
</tr>
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<tbody>
<tr>
<td>Barbados</td>
<td>12</td>
</tr>
<tr>
<td>Belize</td>
<td>2</td>
</tr>
<tr>
<td>Dominica</td>
<td>2</td>
</tr>
<tr>
<td>Grenada</td>
<td>2</td>
</tr>
<tr>
<td>Guyana</td>
<td>2</td>
</tr>
<tr>
<td>Jamaica</td>
<td>84</td>
</tr>
<tr>
<td>Montserrat</td>
<td>1</td>
</tr>
<tr>
<td>St. Kitts &amp; Nevis</td>
<td>3</td>
</tr>
<tr>
<td>St. Lucia</td>
<td>2</td>
</tr>
<tr>
<td>St. Vincent</td>
<td>3</td>
</tr>
<tr>
<td>Trinidad &amp; Tobago</td>
<td>221</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>336</strong></td>
</tr>
</tbody>
</table>

This paper discusses the challenges and opportunities presented to IE educators and researchers in the Caribbean by contemporary issues related to the internet, globalisation, changing demographics, national security, lean and green manufacturing and entrepreneurship. We provide case studies of ongoing initiatives in academia to chart future directions in IE Education and Research by redefining programme focus, bridging the theory/practice gap, developing strategic alliances, and implementing campus-wide initiatives in Entrepreneurship. IE programme stakeholders in the Caribbean are encouraged to examine these global issues to expand the contributions of IE education and research to the region’s economic prosperity.

2. Current Issues in IE Education and Research

2.1 The Internet

The internet has revolutionised business practices and has fostered the development of new business models. Many companies today are focused on transforming themselves to be active participants in the digital economy where e-business is the norm (Turban et al., 2006). In the USA, major companies such as Schwab, IBM, Intel, and General Electric are rapidly moving towards a state where the Internet, intranets and extranets are integrated to conduct ECommerce activities (Slywotzky and Morrison, 2001; Weill and Vitale, 2001).

Although the literature identifies the several benefits of ECommerce (EC) to consumers, organisations and society, several limitations and barriers exist. One of the top 10 barriers to EC implementation identified in a 2000 study conducted by CommerceNet is the lack of qualified personnel. IE educational institutions can address this need by accelerating the use of the Internet to expand access to online training and education for consumers (www.Commerce.net). This is especially important for the islands of the Caribbean, which constitute the UWI System as a new communication technology, can bring courses based at the major campuses at Mona, Cave Hill and St. Augustine to a wider population of students on these Campuses but more importantly to the other islands of the region. Among the technological limitations identified (Turban et al., 2006) are:

- lack of universal standards for quality, security and reliability;
- still evolving software development tools; and
- difficulty in integrating Internet and EC software with some existing (especially legacy) applications and databases.

Also of interest to IEIs are the non-technological limitations such as:

- the absence of mature measurement methodologies to quantify some of the benefits of Electronic Commerce;
increasing online fraud; and
difficulty in securing venture capital due to the failure of many dotcoms.

IE programmes in the Caribbean can readily select one or more of these areas for inquiry and develop relevant curriculum and related research programmes to address this current need. In some instances this may require collaboration with computer scientists and electrical engineers to tackle some of the technological limitations and the establishment of strategic alliances with the business community to develop solutions for the non-technological limitations.

2.2 Globalisation
Global business has become increasingly important to companies as foreign markets constitute an increasing portion of the Total World Market, foreign competitors increase their market shares in one another’s markets, and foreign markets emerge as essential sources of low-cost products, technology, and financial and human capital. Effective information management is of critical importance as companies seek to compete both in the physical marketplace and the virtual marketspace and depend on a reliable information resource (Terpstra, 2006). Industrial engineering can assist Caribbean organisations in the development of robust systems to support both tactical and strategic decision-making in the areas of global sourcing, global logistics, global servicing, global competition, strategic partnerships, global project management, and global supplier relationships.

2.3 Changing Demographics
In the United States, the changing demographics will have a significant influence on the direction of IE education and research. The engineering professorate is rapidly aging and the pipeline of likely replacements is not as full as required as fewer US citizens opt to pursue advanced degrees in Engineering and Science. New immigration rules in the aftermath of 9/11 may exacerbate this problem by discouraging foreign students studying for advanced degrees in IE in the USA. In addition, the great diversity in race, culture and religious beliefs in the USA will result in a different mix in the pool of student talent available to pursue careers in IE. To meet its industrial engineering needs, the USA will increasingly have to place less reliance on non-nationals and develop innovative ways to persuade US high school students to accept the challenge of a career in Industrial Engineering. The Caribbean region is faced with similar challenges. Industrial Engineering as a career needs to be vigorously promoted to high school students, as it is an Engineering discipline that appears not to be understood and valued by both prospective students and employers. Both UWI and UTT should encourage and support some of its best graduates to pursue Ph.D. Degrees in IE thus developing the engineering educators and researchers of the future. Effective mentoring and the support of the professional industrial engineering organisations such as the Caribbean Council of Engineering Organisations (CCEO) and the Institute of Industrial Engineers (IIE) can have a significant impact on a student’s career decision.

2.4 National Security
Since 9/11, national security has been accorded very high priority particularly in the USA and most of the developed countries. Coordinated efforts are in place to develop systems to facilitate the early identification of potential terrorist threats and the initiation of actions to neutralise them (Wise, 2007). Streamlined management systems are required to ensure smooth distribution of vital relief supplies to survivors of natural disasters such as Katrina and the recent devastating hurricanes in the Caribbean (e.g. Ivan). Significant disparities in economic opportunities in the Caribbean can promote the existence of a permanent underclass whose members may require assistance to break free from their economic shackles. Another threat is posed by the HIV/AIDS pandemic which presents policy makers with the ongoing challenge of making optimal allocation of the region’s resources. These areas will have a significant impact on the quality of life of all Caribbean residents and may well benefit from focused IE education and research activity.

2.5 Lean Systems and Green Manufacturing
Lean manufacturing is a team-based industrial philosophy that assists in identifying and eliminating waste by continuously improving product flow (Allen, 2001). Waste is any resource expended within a production system that does not change the fit, form, or function of a part and cannot add value to the manufacturing process. Introduced in post-war Japan, lean manufacturing has evolved into a customer specific process for developing sustainable and flexible business processes (Morgan and Liker, 2006). Critical to every lean production system is a flexible management organisation committed to addressing societal and environmental concerns.
which, in turn, impact the total image of the company (Brown, 1998).

Global competition and slow market growth force some organisations to make drastic changes in their operating strategies in order to compensate for poor productivity, traditional management practices that may prove to be barriers to implementation of any new major programme. Therefore, it can become necessary to restructure the management foundation (Eshbach, 2004) to alleviate the sometimes, chaotic environment that exists within an organisation when the progressions of change are not clearly defined. This restructuring of a plant or an entire company, when deemed appropriate, may enable an organisation to link management efforts to production improvements (Mascitelli, 2007).

Lean manufacturing seeks to produce and deliver the correct quality part or service to the right place, at the right cost, in the right quantity and in an environmentally conscious manner. This goal is especially important for small and medium-sized enterprises (SMEs) in the Caribbean region seeking to compete globally and sustain market growth. The challenges of IEs in lean systems design and manufacturing include the following:

- leveraging and optimising the use of global resources to create lean products for the global market place
- incorporating design reuse and standardisation principles in the design of global product platforms
- designing a lean supply chain to match manufacturing systems
- creating global teams to support lean organisations
- managing knowledge, quality, risk and change in the lean organisation
- designing and manufacturing products and services that are environmentally cognisant of the fragile island states in the region
- managing the life cycle of a product from idea generation through disposal

Of particular interest to industrial engineers in the Caribbean are the synergies to be obtained by combining the waste minimisation ideals of lean systems with environmentally friendly policies that encourage sustainable economic development. The Green Supplier Network developed in the USA (Murray, 2007) encourages large manufacturers to pursue the lean and clean advantage by conducting low-cost technical reviews for their suppliers to identify strategies for improving process lines and using materials more efficiently. Industrial engineers can spearhead efforts in the Caribbean to eliminate the root causes of waste and secure a stronger bottom line while improving environmental performance.

2.6 Entrepreneurship

Entrepreneurship education has been described as “the process of providing individuals with the ability to recognise commercial opportunities and the insight, self-esteem, knowledge and skills to act on them” (Jones and English, 2004). There has been growing interest in Entrepreneurship in academia with the concomitant development of new curricula, infrastructure, and research centers (Bowers et al., 2006). Kuratko (2005) suggests that entrepreneurship has emerged over the last two decades as the most potent economic force the world has ever experienced and recognises the remarkable expansion of entrepreneurship education and the ongoing struggle for academic legitimacy. Heinonen and Poikkijoki, (2006) explore the application of a range of teaching techniques to help university students inculcate entrepreneurial skills and behaviors. Hynes (1996) proposes a model to introduce entrepreneurship education into non-business disciplines while Jones and English (2004) describe a case study which adopts a process of student-centered learning in introducing a new entrepreneurship programme in Tasmania. Other researchers have examined the contribution of Entrepreneurship Centers (Bowers, 2006; Finkle et al., 2006).

Ropke (1998) believes that innovation in developed economies depends on the creation, application and diffusion of new knowledge through academic entities, more specifically, the university. In developing and emerging nations, institutions that use a proactive approach and adopt an entrepreneurial university model can have a positive impact on the socio-economic development of a region (Mian, 2006). In Trinidad and Tobago, for example, both the University of the West Indies (UWI) and the University of Trinidad and Tobago (UTT) have stated a commitment to entrepreneurship and innovation. UWI St. Augustine has identified innovation and entrepreneurship as one of its research pillars in its 2002-2007 strategic plan while UTT has implemented its Industrial Innovation, Entrepreneurship, and Management programme in order to create an environment where all entrepreneurial styles are encouraged and supported. IE may assist in promoting entrepreneurship throughout the Caribbean and create long-lasting partnerships among stakeholders in academia,
industry, and government thus paving a way for economic diversification and sustainable growth and development.

3. Future Directions in IE Education and Research

3.1 Determining Programme Focus

3.1.1 Overview

In determining the appropriate focus for IE programmes in the Caribbean, a Quality Function Deployment framework can be used to assist IE programme stakeholders (such as faculty, students, alumni and employers) in examining the local impact of global issues on IE programmes, designing a winning programme, and implementing programme enhancements. Quality Function Deployment (QFD) has been deployed to provide a structured approach for planning in academia in areas such as revising mechanical engineering curriculum (Ermer, 1995), research planning (Chen and Bullington, 1993), course design (Burgar, 1994), planning enhancements to computer laboratories (Benjamin et al., 1997), improving the quality of teaching (Lam and Zhao, 1998), and reviewing academic programmes (Pitman, 1995). QFD has also been widely used for curriculum planning in international educational environments. In the United Kingdom, QFD was utilised to build a degree programme in the Department of Vision Sciences at Aston University (Clayton, 1995), and designing an MSc degree in Quality Management at the University of Portsmouth (Seow and Moody, 1996). In Sweden, a QFD process was used to develop a Mechanical Engineering Programme which was more responsive to changes in industry (Nilsson et al, 1995). Of particular relevance to industrial engineers is the QFD approach used to improve IE education quality at the Middle East Technical University in Turkey (Koksal and Egitman, 1998). In the case described in the following section, a three-phase modified QFD process was adopted to provide a structured, integrated approach to developing an integrated suite of engineering courses to enhance a business school curriculum.

3.1.2 Case Study – Engineering for Business

The School of Business and Industry (SBI) at Florida A&M University (FAMU) was faced with the challenge of developing a suite of Engineering for Business courses for integration into its business curriculum. Among the benefits envisaged to be reaped by the students were an increased awareness of engineering and technology fundamentals, improved teamwork skills, and enhanced analytical and logical thinking. To realise these benefits, careful attention must be given to curriculum planning to maintain the quality and effectiveness of the programme. In this case, the modified three-phase QFD framework shown in Figure 1 was applied to facilitate the development of an integrated Engineering for Business curriculum.

The three-phase QFD process is used to provide a structured, integrated approach to curriculum planning proceeded in the following phases:

- **Phase 1: Course Planning** - which prioritised the teaching methodologies best suited to deliver critical competencies to students;
- **Phase 2: Course Design** - which identified and prioritised the engineering tools and techniques to be incorporated into the curriculum;
- **Phase 3: Course Implementation** - which assigned the preferred engineering tools and techniques to specific Engineering for Business courses.

![Figure 1. The Integrated 3-Phase QFD Planning Methodology](image)

Successful implementation of this integrated planning process required the conduct of several stakeholder focus groups, surveys and panels to arrive at a consensus on programme enhancements. Table 2 summarises the final QFD matrix which identified the four courses proposed and indicated the engineering tools and techniques to be covered in each course. The robustness of this planning methodology was confirmed via sensitivity analysis.

3.2 Bridging the Theory/Practice Gap and Building Innovation

3.2.1 Overview

To be effective, IE education and training programmes in the Caribbean will be well advised to
pursue the ideal of a seamless curriculum and aim for the effective integration of teaching, research and service activities. This concept is illustrated in Figure 2. Careful attention should be given towards recruiting the right mix of academically and professionally qualified faculty and in pursuing research projects which promote the seamless integration of teaching, research and service. In the case study below, we illustrate how this concept can drive industry/academia collaboration on projects which can promote research of impact and lead to the development of topical teaching material and case studies while providing an opportunity for faculty and students in academia to deliver much needed services to industrial organisations.

![Figure 2. Integration of Teaching, Research and Service in IE Education and Training](image)

**3.2.2 Case Study – NASA Langley**

Over the years, NASA-Langley Research Center (NASA LaRC) in the USA has developed a large portfolio of patents and has been interested in attracting investors to commercialise the more promising ones. One of the technologies identified for review was an Ice Thickness Gauge Technology which addressed the hazards posed by ice build-up on aircraft, buildings and other structures. This technology offered promise because of its ability to distinguish between ice and water and to measure the thickness of ice with a high level of accuracy. Its versatility suggested good potential for deployment in a wide range of applications. These factors prompted its selection as a candidate for a preliminary technology commercialisation study. A team of faculty and students from Florida A&M University was contracted to assess the feasibility of developing a commercially viable business venture using the NASA Ice Thickness Gauge technology. The methodology adopted is summarised in the flowchart in Figure 3.

In the Market Analysis phase of the study, feedback from brainstorming activities of a large novice panel was combined with input from an expert panel of engineering professionals to identify the more promising applications of the technology. In this case, the aircraft industry was identified as the most promising target for the ice gauge technology. In a concurrent Technology Assessment phase, screening heuristics were used to identify a shortlist of more competitive patents.

These finalists were then compared using a scoring model to gauge the competitive advantage offered by the technology over competing patents. The NASA technology was found to offer some advantage over the major competitors. Next, in the Financial Evaluation phase, a deterministic financial model was formulated to assess the technology’s profitability potential over a five-year study period based on cashflow forecasts of revenue and expenditure in the most likely scenario.

Finally, in the Risk Analysis phase, the risk associated with the commercialisation effort was assessed using sensitivity analysis, scenario analysis and simulation modeling.

In this case, the outcomes included the development and implementation of a novel framework for conducting technology commercialisation studies (Benjamin, 2006), preparation of a case study in technology commercialisation for use in Industrial Engineering and Engineering Management classes, several IE conference presentations and journal publications (Benjamin et al, 2005), and written commendations from NASA on the high quality of service provided to the NASA Langley Research Center by the team of faculty and students.

**3.3 Developing Strategic Alliances**

**3.3.1 Overview**

In its 1998 Competitiveness Report (Ministry of Trade and Industry, Singapore 1998), Singapore, a small island state agreed that the goal of its human capital development efforts was “to be a world-class workforce in the 21st century”. These ideas have been adopted in Trinidad and Tobago’s Vision 2020 Report on Science and Technology (2005), and are summarised in Figure 4.
### Table 2. QFD Chart - Course Implementation Phase

<table>
<thead>
<tr>
<th>The WHATs: Engineering Tools and Techniques</th>
<th>The HOWs: Proposed Courses</th>
<th>Fundamental Engineering Concepts</th>
<th>Management Engineering I</th>
<th>Management Engineering II</th>
<th>Management of Technology</th>
<th>Importance (1 - little; 5 - great)</th>
<th>Row Total</th>
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**Rating Scale:** 1 – Weak  3 - Medium  9 - Strong

Strategic industry/academia alliances can assist in equipping the industrial engineers in the Caribbean with these key skills and competencies which are of critical importance in today’s global, competitive and demanding market place. This may require refocusing of the organisational culture of the region’s universities to be entrepreneurial (Grigg, 1994).

Universities have recognised the need to develop new approaches to educate the engineering manager (Kocaoglu, 1994). At Wayne State University (WSU), a leader in industrial engineering and engineering management research and education in the US automotive industry, the Engineering Management Master's Program (EMMP) is one of several programmes in the USA that cross disciplinary boundaries between business and engineering, and are characterised by strategic alliances with industry partners. For over a decade, WSU’s Industrial and Manufacturing Engineering (IME) Department, in partnership with Ford Motor Company and Visteon Corporation, has delivered the Engineering Management Masters Program (EMMP), an innovative applied research and education programme (Chelst et al., 1998). EMMP is a three-year masters degree programme with more than 100 current students and 400 graduates who have been selected by their companies as future leaders. This collaborative programme involving Wayne State University and industry partners (such as Ford Motor Company and Visteon Corporation) targets experienced working engineers. These students study part-time for three academic years (and two summer terms) and earn a single 42 credit degree: Master of Science in Engineering Management. The first two years involve engineering, business and systems coursework. The final year is dedicated to a leadership research
project. One such project is described below involving a team of faculty from Wayne State University and Ford Motor Company (Chelst et al., 2001).

3.3.2 Case Study – Ford Motor Company

The prototype vehicles that Ford Motor Company uses to verify new designs are a major annual investment across its global operations. A team of engineering managers studying for graduate degrees in a Wayne State University programme taught at Ford adapted a classroom set-covering example to begin development of the prototype optimisation model (POM). Ford uses the POM and its related expert systems to budget, plan, and manage prototype test fleets and to maintain testing integrity, reducing annual prototype costs by more than USD250 million. POM’s first use on the European Transit vehicle reduced costs by an estimated USD12 million. The model dramatically shortened the planning process, established global procedures, and created a common structure for dialogue between budgeting and engineering.

Ford uses POM-Predictor to plan for prototype budgets for all the vehicle programmes of Ford Lincoln, Mercury, and Jaguar and will use it for Volvo as soon as it is better integrated into the Ford Motor Company. The model designed a fleet that was 25 percent smaller than originally estimated. Over the 1995-2000 period, the cost of developing prototypes was reduced from over USD1 billion per year by more than USD250 million. During the same period, Ford increased its yearly offering by more than 20 percent. POM-Predictor enabled top management to explore and revise its assumptions about vehicle programmes so as to develop a realistic plan that realised cost savings of 25 percent.

3.4 Developing Campus-wide Entrepreneurship Programmes

3.4.1 Overview

Katz (2003), in chronicling the evolution of entrepreneurship education in the USA from 1876-1999, suggested that the field had reached maturity and expected growth to occur outside business schools and outside the USA. However, Schramm (2006) has asserted that US colleges, universities, and business schools, should be at the very heart of entrepreneurial capitalism and should be making bigger contributions to the changing economic landscape. He argues that higher education should graduate intellectually curious students prepared to make innovative contributions to society and the economy. In support of this philosophy, the Kauffman Foundation, a leader in forging entrepreneurial initiatives on university campuses in the USA, seeks to foster “a society of economically
independent individuals who are engaged citizens, contributing to the improvement of their communities” (www.kauffman.org).

3.4.2 Case Study – Florida A&M University

In an effort to provide an environment for the cross-fertilisation of entrepreneurial ideas, a large business school in the USA, accepted the challenge of leading a campus-wide initiative in Entrepreneurship. Success would require the dismantling of artificial barriers that have traditionally limited the unfettered cooperation and open collaboration that could promote breakthrough changes.

Students would not only acquire traditional business management skills but also obtain an increased awareness of the impact of innovation on the successful planning and implementation of new business ventures. To realise these benefits, careful attention was required during the planning stages to identify the relevant strategies that would represent the best fit with the university’s mission while meeting often conflicting stakeholder expectations. Figure 5 shows the framework proposed to involve all academic departments in a campus-wide entrepreneurship initiative aimed at encouraging the development technology-based ventures, lifestyle businesses, and social entrepreneurship.

Figure 5: Framework for a Campus-Wide Initiative in Entrepreneurship

Figure 6 summarises the single-phase Quality Function Deployment framework developed to design the campus-wide entrepreneurship initiative. This process enabled the prioritisation of the entrepreneurship development strategies best suited to meet the needs of the various stakeholder groups.

In this case, development of an undergraduate major, establishment of a doctoral programme, and launching a research-oriented Entrepreneurship Center that would also provide consulting services emerged as the top priorities. At the other extreme, the lowest priority was accorded to developing a business incubator, initiating an Entrepreneur-in-Residence programme, and offering seminars and professional development courses. The results of a Sensitivity Analysis in which the criteria weights and rating schemes were varied showed that the QFD framework was fairly robust with the entrepreneurship development strategies in the highest and lowest ranked tiers remaining unchanged. This planning framework can be readily adopted by Caribbean leaders in industrial engineering seeking to develop winning strategies to stimulate entrepreneurial activities in the region.

4. Future Directions in the Caribbean

4.1 Determine Programme Focus

Contemporary issues related to the internet, globalisation, changing demographics, national security, lean and green manufacturing, and entrepreneurship present challenges and opportunities for IE educators in the Caribbean. To ensure an effective response, key stakeholders in the Caribbean community must be engaged in determining the appropriate focus of the region’s IE programmes. Arriving at a consensus on the specific competencies to be inculcated in IE graduates and the mechanisms to be put into place to foster inter-institutional co-operation and collaboration can assist in determining the appropriate focus of IE programmes in the Caribbean. This will enable decisions to be made on issues such as the research agenda to be pursued, new curriculum offerings to be
developed, and the emphasis to be placed on online courses.

The region’s government, business and industry stakeholders have suggested that the UWI graduate has been lacking in the ‘softer skills’ which often enable students to better transition to the “world of work” or the engineering profession. The ASME Professional Practice Curriculum (ASME International, 2006) summarised in Figure 7 provides an excellent benchmark for adoption by the IE faculty at UWI and other engineering institutions in the Caribbean.

In recent years there has been progress in the Faculty of Engineering with respect to teaching and learning so as to better prepare graduates through enhanced skills in Communication, Leadership, Team Building and Project Management, Professional Ethics, Innovation and Entrepreneurship and Health, Safety and Environment. The IE programme and its staff of the Faculty of Engineering of the UWI should be a leading player in these efforts as there is much more to be done.

In developing an IE research agenda, care should be taken to ensure that the R&D efforts of the IE faculty are complementary to the undergraduate and postgraduate teaching that is being delivered and continue to focus on helping business and manufacturing enterprises in the Caribbean particularly the SMEs, to compete effectively not only in the local context, but also in the wider regional and global marketplace. Also required are the development or adoption of new methods for learning and the promotion of wider access for undergraduate and postgraduate education through new Computer Aided Educational technologies.

4.2. Developing Strategic Alliances
In this increasingly inter-connected world, UWI’s IE programme must pursue strategic alliances with the professional engineering organisations locally, regionally and internationally, e.g. the Association of Professional Engineers of Trinidad and Tobago (APETT) and the other Regional Professional Engineering Organisations, the Board of Engineering of Trinidad and Tobago (BOETT), the Council of Caribbean Engineering Organizations (CCEO), Institute of Industrial Engineers (IIE), the Institution of Mechanical Engineers (IMechE, UK), and American Society of Mechanical Engineers (ASME), etc. It must also aggressively establish links with

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**Figure 7.** The ASME Professional Practice Curriculum
Source: Abstracted from ASME International (2006)
local and regional industries, and academic institutions in other countries.

The creation of the Centre for Enterprise Research Integration (ERI) within the Department of Mechanical and Manufacturing Engineering of the UWI whose principal objective is “to provide an environment for teaching, research and extension in areas such as e-Enterprise Operations (e.g. e-logistics, e-supply chain and e-business) and Computer Integrated manufacture, through the integration of Simulation, Shop Flow Control, Instrumentation, and Business Enterprise Management Systems” and which would work closely with Industry, is a step in the right direction. The Faculty’s Engineering Institute can also play a major role in creating linkages with Government, business, and industry.

5. Discussion and Conclusion
IE education and research in the Caribbean is at a critical stage in its ongoing evolution as it now needs to re-position itself to address several major challenges and exploit opportunities. The case studies described in this paper report strategies adopted at institutions in the USA in the hope that these stimulate a search for innovative enhancements to IE programmes in the Caribbean.

Our review of UWI Faculty of Engineering with its experienced faculty, established undergraduate and graduate programmes, supportive and faculty-friendly environment suggests that it has great potential to develop a world-class industrial engineering programme. To date, UWI has provided IE education and training for a large number of very successful professionals who now occupy leadership roles in business, academia, and government organisations in the Caribbean. This paper seeks to contribute to the dialogue and debate necessary to ensure the continuous review, re-examination, and re-visiting of the IE programme’s mission to better meet the challenge of developing industrial engineers who will continue to have a significant impact on the sustainable, socio-economic development of the Caribbean region.

UWI, a leader in IE education and training in the Caribbean, should aim to be agile by developing nimble and responsive programmes, adopt the entrepreneurial university model, encourage academic rigor by delivering challenging course content, pursue strategic alliances with professional organisations, companies and other universities, and adopt strategies to recruit, inspire and retain a cadre of highly motivated IE faculty. Ongoing efforts are required to ensure a careful review of global trends in IE, arrive at a consensus among stakeholders on the way forward, and boldly implement the new vision.

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Conceptualising Project Management:
A Caribbean Perspective on Planning, Execution and Externalities

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Abstract The current project management system in the Caribbean Region is constrained by identified institutional and policy issues which restrict project management performance and effective accountability of task. It has resulted not only in rapid and dramatic deterioration of project successes but it has also reduced the attractiveness for launching developmental projects in the Region. This, in combination with inept human resources and scarce financial resources, has constrained the Caribbean Regions’ social and economic progress in relation to maximising on the benefits to be derived from various projects. Based on survey data obtained from thirty project managers in the region, this research paper highlights the features of a project and key concepts in project management that need to be adapted by Regional project managers to enhance the chances of project success. A summary write-up of the findings and lessons learnt from project managers in the Region is also documented in the research.

Keywords: Project management, project planning, project execution and institutional strengthening

1. Introduction
Ever thought about mastering the art of juggling? Throwing and catching many objects into the air in quick succession. Not too difficult? How about walking on a tight rope at the same time, just to up the ante. This puts in perspective the task faced by project managers around the world on a daily basis.

Due to expansion and volume of project portfolios, around the Region, the role of the project manager has been identified not just by how good they can juggle tasks, but also as the key to the successful completion and delivery of any given project. The project manager is responsible for the successful overall planning, initiation and execution of these major capital projects and effective communication with executives and key stakeholders. While the ways projects are being used within units change, the practices of project management itself are evolving as well. The key skills of a project manager have changed in recent years, in that projects themselves have become much more complex and filled with disastrous turning points and critical areas that need to be properly managed to achieve the ultimate goal of success.

It is therefore foreseeable to some extent that some projects will not make it to the finish line. The reasons why projects fail are many, and the reasons for success are a few. Successful projects are still an elusive goal at many companies and government institutions. The project may be complete but it may be late, over budget, or fail to satisfy their original goals 100%. Project management expertise is the bridge to this phenomenon. A successful Project Manager understands that there is a correlation between planning, execution and the external factors of the environment.

The objective of this research is to identify areas where institutional capacity needs strengthening so as to improve the programming and management of the Regional development projects and to improve donor coordination, particularly in relation to the planning, execution and monitoring. The insights for the development of this research stem around the premise that in order for a project to be successful, project planning, execution and externalities have to be in alignment and synergize to maximise on
benefits. It is therefore under the criterion: planning, execution and externalities that the author approaches the issue to formulate a remedy and analyse the hypothesis.

The paper will focus on improved monitoring and coordination and identification of more efficient ways and/or best practices to be adapted within Regional projects. Finally, the recommendations will offer appropriate acquisition and systems implementation methodologies, which can be applied during the various phases of the project management.

2. Project Definition and Features
A project is an undertaking that encompasses an entire set of activities having a definable starting point and well-defined set of objectives, the delivery of which will signal the completion or termination of the project. Projects are usually required to be accomplished within limited resources. According to PMI (2004), projects are defined as having a means of organising activities that cannot be addressed within the organisations’ normal operational limits.

All projects share some common features. They have a clear and agreed upon scope and set of objectives, a defined cycle or life span, and they have specific requirements as they relate to cost, time and quality. Each of these features will be defined so as to quantify the viewpoint for the research.

2.1 Project cost
Gido and Clements (2006) state that cost planning starts with the proposal for the budget. It is during the development of the proposal by the project manager and the project team that costs are estimated. The cost for the project is generally recognised as necessary for the performance of the project. It must be reasonable and realistic as it is allocated to the project task at hand. A specific project may only be charged that portion of the cost which represents the direct benefit to that project, and the cost must be treated consistently with other similar costs incurred in like circumstances in accordance with generally accepted accounting principles.

Since costs are estimated before the work actually begins, completion of the budget gives team members a chance to ask themselves whether they really want to do this project, given the cost (Luecke 2004). The management of project cost is quite key to the successful completion of a project. According to the PMI (2004) project management cost includes the processes involved in planning, estimating, budgeting, and controlling costs so that the project can be completed within the approved budget.

2.2 Project time
The key to quantifying time in project management is to allocate it towards particular task as identified in the activities in the project breakdown. The project manager must estimate the effort required for the completion of each task. Gido and Clements (2006) stipulate that good project managers manage their time well. Projects require a lot of energy because they involve many concurrent activities and unexpected events. To make optimal use of the time available, project managers have to have self-discipline, be able to prioritise, and show willingness to delegate. The more practice in this area the more accurate estimates become. Once all the estimates for the task have been documented, a summation is done to finalise the total time required for final delivery.

The project activities need to be specifically arranged as some have dependencies and others need to be prioritised in some cases tasks are set out in a form to be documented in a project schedule. Based on these interactions between the tasks and activities, the length of the overall project can be confined. According to PMI (2004), the processes concerning the timely completion of a project need to be properly managed. These processes stress activity definition, activity sequencing, resource estimating, duration estimates, schedule development and controls.

2.3 Project quality
The project quality should be defined and written down as part of the objectives of the project proposal to provide the project team with easy access to quality requirements. A series of activities are identified as key to determining what is intended to deliver a finished project while focusing on achieving project deliverables. These activities are defined on the basis of the quality standards set by the organisation delivering the project, however they are based on the agreed project proposal’s objectives. The PMI (2004) describes project quality management as the process involved in assuring that the project will satisfy the objectives for which it was undertaken.

2.4 Project Management
Stuckenbruck and Zomorrodian (1987) state that
project management is a relatively new practice that attempts to achieve planned objectives within specific time and cost limits through optimum use of resources, using integrated planning and control system with a single point of responsibility and accountability. Further to this definition, the Project Management Institute defines project management as the application of knowledge, skills, tools and techniques to project activities to meet project requirements. Therefore, it entails finding a balance between the above three features, and it is finding this right equilibrium that project management processes focus on. In other words, a common project management conundrum is how to achieve an optimum balance between the flexibility that the project demands and the efficiencies within which the project has to be delivered. Navigating this tight rope is a core function and the sole reason for the project manager.

3. Essential Concepts and Techniques

Comprehensive project management is defined in the literature based on cost, time and quality. The development process as adopted by the Project Management Body of Knowledge (PMI, 2004), as well as by most modern methodologists, is best described in terms of history. Early academics noted two major causes of project failure. The first was that too many design flaws were being discovered during execution where it is difficult, expensive, and sometimes impossible to remedy. The second problem was that the scope of many projects seemed to expand uncontrollably as the project proceeded.

Hussain and Wearne (2005) state that organisation, time and resources together with project definition, cost, contracts and change are the topics given the most attention in leading journals and textbooks as revealed by Cleland (1994), Meridith and Mantel (2000), Morris (1994) and Turner (1999); and they correspond with the factors defined as the main threats to successful project management, Clarke (1999), Munns and Bjermi (1996), Pinto (1998) and Yeo (2002).

3.1 Planning

Cost analysis capabilities can provide a valuable input to major decisions such as those involved in acquiring new systems for the project. A thorough analysis of the cost-of ownership vs lease arrangements, made up of acquisition costs, through to variable costs such as maintenance and operational costs, potential system upgrades or refits, and the costs of system retirement and disposal, is clearly essential if we are to assess the cost-effectiveness of new or existing systems within which the project is to encompass. This approach will identify dollar-based costs. Decision-making on options for future project management decisions will need to relate these dollar costs to the non-dollar value capabilities which are associated with each activity; each decision is a cost/benefit decision, and this will focus attention on the development of improved decision-making aids.

All reviews and evaluations should be based on a tailored approach, which considers: project-specific attributes; review/decision objectives; and project size, cost and complexity. These reviews and evaluations form a valuable body of knowledge for future projects and therefore should form the documented foundation for lessons learned reports. The lessons learned process provides useful information that can be employed to inform and train current and future project teams. Lessons learned can be derived from prior experience, evaluation activities, directed action items, issues, concerns, accidents, incidents, and corrective actions.

The acquisition strategy should be tailor made based on the size, risk, and associated complexity of the project. Tailoring may involve consolidated decisions, altering approved documents or substituting documents to match project objectives. In most cases, tailoring does not give the project manager the right to change things as he sees fit; nor does it imply the omission of essential elements in the acquisition process, such as risk and alternative analysis, critical decisions, cost ranges and variances, contract types, competition and major milestone, which are necessary for all projects.

An important component of any project is budget expectations, i.e. the preparation of a detailed budget and budget narrative, which links the funding being requested with specific activities or elements of the proposed project. It is of paramount importance that the project manager uses his best judgment when estimating project expenses. In establishing cost and budget expectations the project manager must be consistent and realistic, and where necessary, seek cost advice early in the process as the proposed budget will be reviewed and negotiated by sponsors to ensure that it meets the goals and objectives of the proposed project and that it is consistent with the policies of the governing bodies.

In relation to budget expectations, there are key areas that project managers must be cognisant of, and these include: potential problems due to unanticipated costs or under-estimated costs and
scope creep due to failure to understand the scope of work, or wrong assumptions, or incomplete information.

Managing optimism may well be a leading contributor of project failure, as a factor of blindness to project risks. Barnes and Warne (1993) state that understanding the nature of risks of major projects is one of the more recent developments in the science of project management. The project manager may find himself managing the impact of positive and negative emotions on project performance and project team resilience, two areas that have varying views on optimism.

In addition, while managing projects, consideration will have to be given to the effects of personal style as it relates to leadership, communication, and conflict on team effectiveness and perceptions. Managing optimism also entails creating an environment for constructive conflict and paving a path for how to accomplish it for the benefit of the project, mainly through team synergy, effective meetings, personal and mutual accountability and moving from compliance to commitment through building confidence and sanguinity. All these can be leveraged through a dynamic, learning organisation filled with enthusiasm.

3.2 Execution

3.2.1 Requirements control
All projects must include a well-defined problem statement with well-defined work plan and technical requirements that assure the project objectives satisfy the overall project scope. Requirements must be thoroughly documented and understood by the project manager and his team. Changes to requirements must be determined to be within the scope and require signed approval by the project sponsor. Requirements must be managed throughout the life of the project.

During execution, the requirements establish and maintain an understanding and agreement of the scope and capabilities of the project. Requirements statements, which will evolve over the life of the project, form the basis for estimating, planning, performing, and tracking the project’s activities and are critical to obtaining acceptance of the deliverables at the end of the project. Control of requirements is directly related to control of the project.

3.2.2 Scheduling and Costing
Schedules are used to plan and depict practical, time-phased, hierarchical activities and events taking place within the project. They contain activities, logical relationships, milestones, duration, resource requirements and constraints. Scheduling is inextricably tied to the project’s timeframe and is essential to developing a cost estimate for all the activities to be performed. Development of schedules is required early in the project formulation and conceptualisation stage.

In most cases it is advisable to set up a preliminary schedule range, which would highlight high-level milestones and any critical points in the project, which may need special attention. Cost estimates are required at various points in a project’s life cycle. Determination of estimating methodology and approach is based on the level and availability of scope definition and documentation, and the resources required for developing the cost estimate.

3.2.3 Human resources allocation
The allocation of human resources to each project is a very important phase of the decision-making problem. Anderson (1992) states that a project manager should clearly define project objectives, document and communicate them to the project team. These practices are implemented through the project manager’s capability to plan and elicit the commitment of the project team toward achieving project objectives.

Therefore, it is clearly understood that performance and quality of projects strongly depend on human resources capabilities. Consequently, one of the key factors for successful projects is how to be excellent in human resources allocation, taking into account their personalities and abilities. Through training and through the reallocation and/or retrenchment of selected staff, the project manager will assist in bringing human resources to their appropriate quantity and quality to perform core functions within the work plan for the project.

3.3 Externalities
Experience has shown that excellent project managers function at a level well beyond the classic functional management. Even though Project Managers must subscribe to the rational and scientific approach to management, they also have to adopt a new mind-set of flexibility, one of expecting goals and means to be resolved simultaneously and interactively given the many constraints. Project managers must therefore be up to date with the many areas of the environment impacting their project.

Further to this, Korton (1980) highlights that
many western management practices were developed to improve already well-developed organisational settings. These individual techniques or practices are often transplanted into less institutionalised environments in developing countries for the purposes of system development.

3.3.1 PEST drivers
Project managers should conduct horizon scanning and identify any assumptions in the current environment, which may have an impact on any of the project stages. This will include identifying PEST (i.e. Political, Economic, Social, and Technological) drivers and uncertainties from other sources that may influence the project and/or the financial system in the jurisdiction in general, and existing assumptions made about the future within the current project parameters.

3.3.2 Cultural issues
Stuckenbruck and Zomorrodian (1987) highlight that the issue of culture is a prime focus in today’s literature and constitutes the ‘bottom line’ in any discussion concerning the transfer of management techniques or models from one country to another, particularly in the case of developing countries, and the Caribbean is of no difference. In planning projects, potential cultural issues should be taken into account at each stage in the project cycle. In the earliest stages of project design, background research should be carried out to determine whether there are cultural issues to be addressed.

In cases where cultural issues are likely to be a problem, a cultural specialist should be retained as part of the execution team for the project. By taking cultural issues into account from the beginning, project managers have a better understanding and can hence negate any risk that could have been raised due to cultural differences. As a result project managers are better able to build capacity to manage cultural issues in a sustainable manner and strengthen the base for diversity in the project team.

4. Research Methodology
This section presents a detailed overview of the research methodology adopted in this study, outlining major issues related to the design, instrumentation, sampling and data-collection procedures.

4.1 Design and Instrument
A survey research design was primarily used to capture data from a sample of project managers in the Caribbean in order to address this study’s main research question on how to improve various issues in project monitoring and coordination, and also to identify more efficient ways and/or best practices to be adapted within Regional projects.

Background information on each project was collected through a questionnaire and additional information was sourced by searching each institution’s internet website and by contacting the institution directly. The questionnaire sought to examine respondents’ perceptions of a current project being undertaken or the last project that they managed. A small number of initial contacts were used in a pre-test during the development of the questionnaire and it was subsequently modified for ease of use. The questionnaire covered issues related to the purpose of the project, the cost and benefits, data gathering techniques, funding issues, capacity building and stakeholder analysis.

More importantly, respondents’ perceptions of several major issues in project monitoring and evaluation on particular projects for which they were responsible were obtained, their perceptions of best practices and methods, and recommendations for improvement. The questionnaire also contained several open-ended questions to allow respondents to indicate their views and recommendations so as to permit a qualitative assessment in this research. The data from the returned questionnaires, along with additional notes taken were collected and analysed.

4.2 Sample and Data Collection Procedures
The sample under study in this research was 30 project managers listed as participants in a specialised project management program being sponsored by various governments and private sector institutes. The countries participating in the research include Barbados, Jamaica, Trinidad, St. Lucia, St. Vincent, and Dominica. Overall, thirty respondents responded to the survey instrument. These respondents were chosen because of their experience in project management, evaluation and monitoring. Respondents were responsible for at least one major project in their professional career as a project manager.

5. Results
The section presents the main findings regarding Caribbean project managers’ perceptions concerning several issues of project management, evaluation and monitoring and the practices underlying these issues. Various issues addressed in this research included
the sampling and methodological issues of project evaluation and monitoring, the impact of the project on stakeholders (i.e. stakeholder analysis) and stakeholder issues, and the perceived best practices in project management, evaluation and monitoring. The quantitative data have been presented using frequencies/percentages, and mean scores, and the qualitative data have been summarised using thematic analyses.

Respondents were sampled from various countries in the Caribbean including Barbados, Dominica, Jamaica, Grenada, and Trinidad and Tobago. Majority of respondents (i.e. 95%) worked for governmental agencies or Ministries. Approximately 85% reported 5 years or less of project management experience, while only 15% reported over 5 years of project management experience. In total, 70% of respondents currently held a first degree, 26% held a post-graduate degree, and 4% held a Diploma.

5.1 Sampling and Methodological Issues involved in Project Evaluation and Monitoring

Respondents were also asked to indicate whether several methodological issues were considered in the evaluation of (and monitoring of) a project of which they were in charge (i.e. a current project or a more recent one). More than one third (i.e. 36%) indicated that they used ‘other’ (non-probability) sampling techniques, and 26% reported that they used random sampling (see Table 1).

Majority of respondents (i.e. 78%) reported that, during sampling, efforts are made to reach marginalised, or disadvantaged participants (see Table 2). Over half (i.e. 52%) indicated that issues of accessing participants were satisfactorily dealt with in the methodology, and only 9% indicated that certain participants were excluded because of exhibited difficulties. A majority of respondents (i.e. 61%) indicated that the findings were intended to be representative of a typical group of participants. Some 63% of respondents also indicated that participants were sufficiently well-selected for representativeness (see Table 2).

5.2 Stakeholder Issues in Project Evaluation and Monitoring

Respondents reported on several stakeholder issues associated with project evaluation and monitoring. Table 3 shows the results of the data. With respect to dissemination of project results, more than half (52%) reported that stakeholders involved receive short reports on the main findings or other forms of feedback.

<table>
<thead>
<tr>
<th>Table 1. Sampling Methodologies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampling Methodologies</strong></td>
</tr>
<tr>
<td>Systematic sampling</td>
</tr>
<tr>
<td>Random sampling</td>
</tr>
<tr>
<td>Stratified sampling</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Methodological Issues in Project Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Methodological Issues in Project Evaluation</strong></td>
</tr>
<tr>
<td>Were efforts made to reach marginalised, or disadvantaged participants?</td>
</tr>
<tr>
<td>Were issues of accessing these participants satisfactorily dealt with in the methodology?</td>
</tr>
<tr>
<td>Were any participants excluded because, for example, they exhibited difficulties with speech and learning?</td>
</tr>
<tr>
<td>Are the findings intended to be representative or typical of a certain group of participants?</td>
</tr>
<tr>
<td>Have the participants in the study been sufficiently well selected to support these claims?</td>
</tr>
</tbody>
</table>
Just over one third (i.e. 35%) reported that the capacities of stakeholders and their preferences for receiving feedback were taken into consideration, however an equal proportion (i.e. 35%) indicated that this did not occur. Majority of the respondents (i.e. 61%) indicated that the research, monitoring or evaluation activity had an impact on stakeholders’ capabilities, on the degree to which their environment was supportive of their participation, and a further majority (i.e. 44%) reported that this impact was planned for in the design stages. Interestingly, 39% of the respondents indicated that stakeholders involved were not realistically prepared for this expected impact.

Furthermore, most respondents (i.e. 48%) were unsure as to whether the approach was reflex, in that those involved in data collection and analysis critically discuss their own prejudices. Just about half of the respondents (i.e. 48%) indicated that researchers involved in project evaluation try to balance impartial assessment with respect to participants’ worth and dignity.

5.3 Perceptions of Project Monitoring and Evaluation Best Practices

Respondents were asked to indicate the extent to which a number of project monitoring and evaluation practices were being utilised at the highest level (i.e. the level of best practices). Table 4 shows the means and standard deviations regarding the monitoring and evaluation practices of these projects. Responses were scored on a seven-point scale ranging from 1 (i.e. lowest level) to 7 (i.e. highest level).

It is important to note here that all practices were rated moderately high where mean scores ranged from as low as 4.42 for dissemination of monitoring and evaluation results to as high as 5.10 for selection of indicators. The top three project monitoring and evaluation practices (i.e. those practices that were practised at the highest level) cited were: 1) selection of indicators, 2) data collection methodologies, and 3) developing conceptual framework.

5.4 Perceptions of Project Management Best Practices

Respondents were asked to indicate the extent to which a number of project management practices were being utilised at the highest level (i.e. the level of best practices). Table 5 shows the means and standard deviations regarding these project management practices. Responses were scored on a seven-point scale ranging from 1 (lowest level) to 7 (highest level). It is important to note here that all practices were rated moderately high where mean scores ranged from as low as 4.50 for project planning using the project lifecycle to as high as 5.05 for project quality management. The top three project monitoring and evaluation practices (i.e. those practices that were practised at the highest level) cited were: 1) project quality management, 2) project budgeting, and 3) project cost management.

<table>
<thead>
<tr>
<th>Stakeholder Issues in Project Evaluation</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the stakeholders involved receive short reports on the main findings or other forms of feedback?</td>
<td>52%</td>
<td>22%</td>
<td>26%</td>
</tr>
<tr>
<td>Were the capacities of stakeholders and their preferences for how they receive feedback taken into consideration?</td>
<td>35%</td>
<td>35%</td>
<td>30%</td>
</tr>
<tr>
<td>Did the research, monitoring or evaluation activity have any impact on stakeholders’ capabilities, on the degree to which their environment was supportive of their participation?</td>
<td>61%</td>
<td>9%</td>
<td>30%</td>
</tr>
<tr>
<td>Was this impact (above) planned for in the design?</td>
<td>44%</td>
<td>17%</td>
<td>39%</td>
</tr>
<tr>
<td>Were the stakeholders involved realistically prepared for the expected impact, whether small or large?</td>
<td>26%</td>
<td>39%</td>
<td>34%</td>
</tr>
<tr>
<td>Was the approach reflexive in that those involved in data collection and analysis critically discuss their own prejudices?</td>
<td>26%</td>
<td>26%</td>
<td>48%</td>
</tr>
<tr>
<td>Did researchers try to balance impartial assessment with respect for participants’ worth and dignity?</td>
<td>48%</td>
<td>13%</td>
<td>39%</td>
</tr>
</tbody>
</table>
Table 4. Project Monitoring and Evaluation Best Practices

<table>
<thead>
<tr>
<th>Project Evaluation Best Practices</th>
<th>Mean</th>
<th>SD</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing a Conceptual Framework</td>
<td>4.89</td>
<td>1.61</td>
<td>3</td>
</tr>
<tr>
<td>Sampling techniques</td>
<td>4.78</td>
<td>1.56</td>
<td>4</td>
</tr>
<tr>
<td><strong>Selection of indicators</strong></td>
<td><strong>5.10</strong></td>
<td><strong>1.41</strong></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>Designing of Data Collection Instrument</td>
<td>4.63</td>
<td>1.49</td>
<td>7</td>
</tr>
<tr>
<td><strong>Data collection methodologies</strong></td>
<td><strong>4.90</strong></td>
<td><strong>1.62</strong></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>Preparing the data for</td>
<td>4.44</td>
<td>1.61</td>
<td>9</td>
</tr>
<tr>
<td>Coding/Analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Analysis and Interpretation</td>
<td>4.65</td>
<td>1.57</td>
<td>6</td>
</tr>
<tr>
<td>Use of Management Information System</td>
<td>4.68</td>
<td>1.82</td>
<td>5</td>
</tr>
<tr>
<td>Dissemination of Monitoring/Evaluation results</td>
<td>4.42</td>
<td>1.77</td>
<td>10</td>
</tr>
<tr>
<td>Developing a Conceptual Framework</td>
<td>4.89</td>
<td>1.61</td>
<td>3</td>
</tr>
<tr>
<td>Sampling techniques</td>
<td>4.78</td>
<td>1.56</td>
<td>4</td>
</tr>
</tbody>
</table>

**Note.** Bold-faced practices indicate the top three best practices in project evaluation and monitoring perceived by respondents. Ranks indicate perceived importance of each practice.

Table 5. Project Management Best Practices

<table>
<thead>
<tr>
<th>Project Evaluation Best Practices</th>
<th>Mean</th>
<th>SD</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project planning using the project lifecycle</td>
<td>4.50</td>
<td>1.57</td>
<td>9</td>
</tr>
<tr>
<td>Project scope management</td>
<td>4.91</td>
<td>1.44</td>
<td>4</td>
</tr>
<tr>
<td>Project time management/scheduling</td>
<td>4.66</td>
<td>1.52</td>
<td>8</td>
</tr>
<tr>
<td><strong>Project costs management</strong></td>
<td><strong>4.95</strong></td>
<td><strong>1.49</strong></td>
<td><strong>3</strong></td>
</tr>
<tr>
<td>Project quality management</td>
<td>5.05</td>
<td>1.21</td>
<td>1</td>
</tr>
<tr>
<td>Project human resource management</td>
<td>4.69</td>
<td>1.64</td>
<td>6</td>
</tr>
<tr>
<td>Project communication management</td>
<td>4.73</td>
<td>1.35</td>
<td>5</td>
</tr>
<tr>
<td>Project procurement management</td>
<td>4.68</td>
<td>1.81</td>
<td>7</td>
</tr>
<tr>
<td><strong>Project Budgeting</strong></td>
<td><strong>5.00</strong></td>
<td><strong>1.54</strong></td>
<td><strong>2</strong></td>
</tr>
</tbody>
</table>

**Note.** Bold-faced practices indicate the top three best practices in project evaluation and monitoring perceived by respondents. Ranks indicate perceived importance of each practice.

6. Summary of Qualitative Findings and Comments

This section presents a summary of the main findings derived from the survey data obtained in this research. It incorporates qualitative data that emerged from the open-ended questions within the survey regarding participants’ review of current project management practice, and recommendations for improvement. These are summarised in Table 6. Categories for strengthening were derived from thematic analyses of the qualitative responses. Specific comments from respondents were also mentioned. Besides, some lessons learnt by project leaders are highlighted as follows:

1. Successful implementation of a project requires strong relationships and commitment between the major project players.

2. The sponsor should give ample support to the project team identified by providing adequate funding support, resources to pursue the project, meet training and capacity building needs for the new institutional framework.

3. Persons of requisite qualifications, experience, aptitude and motivation levels should adequately staff the project team.

4. Adequate training, equipment and knowledge infrastructure building budgets should be provided for the institutions pursuing the projects.

5. Modern project management techniques, organisational structures, policy guidance, regulatory interventions and planning and programming tools should be adopted for project delivery efficiency.
Table 6. Summary of Participants’ Views and Recommendations

<table>
<thead>
<tr>
<th>Category for Strengthening</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Planning, budgeting and programming systems</td>
<td>Adopt planning, budgeting and programming systems that have analytical tools that can be used for work plans and scheduling.</td>
</tr>
<tr>
<td>2) International financial management methods</td>
<td>Project Managers need to establish updated accounting and reporting systems which are acceptable by all key stakeholders. There is a further need for Project Managers to implement suitable accounting software packages. Within larger projects, all the accounting and financial systems should be computerised. The system utilised should be compliant with the Regional Accounting Standards and Generally Accepted Accounting Principle (GAAP).</td>
</tr>
<tr>
<td>3) Management Information Systems</td>
<td>Further development and implementation of Management Information Systems to improve documentation and information flow for strategic decision making.</td>
</tr>
<tr>
<td>4) Human Resource Management</td>
<td>Project managers need to develop and implement human resource development strategies and training programs that fit into the organisations overall strategic plan. Institutions involved in more than one project should have training and development policies for its staff recommending that every employee will undergo at least one training program in each calendar year. Institutions that have several project portfolios should have HR management staff that expands current Training &amp; Development Plan with a three to five year perspective. Various training programs could be conducted in-house or in outside institutions for project team employees.</td>
</tr>
<tr>
<td>5) Partnerships</td>
<td>Update and implement guidelines for private sector and government participation in developmental projects in accordance with other more lucrative working relationships.</td>
</tr>
</tbody>
</table>

6. Strong monitoring and evaluation systems should be adopted to be able to monitor project status and delivery of desired outcomes

7. Conclusions
For a successful project delivery, it is essential first to establish robust definitions and structures for the three criterions: planning, execution and externalities. Mastering the critical areas in the project related to institutional capacity, project management strategies, stakeholders’ analysis, and resources are all vital to the success of the project.

Once the elements of criterion have been realised and are in place with the five categories for strengthening institutional capacity, the result will be a structured working model for successful project delivery. For an effective project delivery, there has to be a continuous review and evaluation of the elements of project, process sets and information systems. Based on these evaluations, work plans should be adopted by project organisations to enhance sustainability.

In the case of the 30 project managers interviewed several categories were observed and analysed. In the area of planning, the project managers appeared to be most comfortable with the task that needs to be performed especially as it related to selection of indicators, data collection methodologies and developing conceptual frameworks.

However, there were some areas that would fall under the planning stage that the project managers appear not to be comfortable with and these included: designing the data collection instrument and preparing the data for coding and analysis, though this was the case, it is not worrisome as a third party could quite easily join the project team to facilitate in these areas without compromising the project. In the area of execution, the project managers were strong in quality management and cost/budgeting techniques, however it was quite noticeable that scheduling/time management was one of the weakest links and was therefore at the heart of most of the project failures.

In the area of externalities, especially as it related to beneficiaries, the project management techniques were weak in the dissemination of results and the use of results for decision-making. This research therefore highlights that Caribbean projects, once analysed based on the three categories of planning,
execution and externalities, are viewed to be out of alignment and therefore do not synergise to maximise on any great potential benefits, hence the projects are categorised as unsuccessful in most cases.

This research therefore sets up an argument for approaching project management in a more comprehensive way which shares the premise that in order for a project to be successful, project planning, execution and externalities have to be in alignment and synergise to maximise on benefits. It has also shown that by identifying needs for continuous review of institutional arrangements and project management processes; organisational capacity building in conformity with the changing environments will create a positive impact on the effectiveness, efficiency and successful performance delivery of a project. Project management can therefore be used in the Caribbean as a tool for reform and change and can be an effective platform for demonstrating the true value of projects to the Caribbean.

In addition, this research highlights that the quality of the project manager is critical to achieving project success, as the project manager is key to implementing the project, however, the parameters for gauging the level of success can only be judged based on the relationship between the project performance and the attributes of the project manager, which is an area not explored in this research.

For individual companies and Government institutions, the research provides a benchmark and a guide for project managers to review their shortcomings and challenges in managing projects. Most of what being identified as issues in Caribbean projects are common in other Regions and therefore need to be anticipated and managed better, for example, risks of extra cost and delays due to changes can all be eliminated. Special attention could be placed on lessons learnt to identify best practices from past projects to handle these issues in a more comprehensive manner.

Finally, this study represents only a descriptive account of the project managers’ views of how to improve current project management practice. The generalisability of these findings is restricted given the relatively small sample size (n = 30). Caution should be used when interpreting and generalising these findings.

References


Biographical Notes:

Paul Pounder holds a BBA (Hons) with a concentration in entrepreneurial studies from Brock University in Canada and a PhD in Manufacturing and Mechanical Engineering from the University of Birmingham in England. He is currently employed as a lecturer at the University of the West Indies and researches in the areas of general management practices, project management and evaluation, and business development of SMEs in developing countries.

Dwayne Devonish is a teaching assistant in the Department of Management Studies at the University of the
West Indies. His main research interests include human resource management, organisational behaviour, research methodology, and work and organisational psychology.
Industrial Engineering and the Application of Value Engineering in CARICOM Countries

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Abstract The World Book Encyclopedia defines Industrial engineering as being concerned with planning techniques of working, and the uses of machines in industry. It is the branch of engineering that concerns the development, improvement and evaluation of integrated systems of people, knowledge, information, equipment, energy, material and processes and draws upon the principles and methods of engineering analysis and design, to specify, predict and evaluate the results to be obtained from such systems. Industrial engineers are specialists in the field and work to eliminate wastes of time, money, materials, energy and other resources. The tools and techniques employed by industrial engineers can be utilised by entrepreneurs and organisations to create sustainable business enterprises in Caricom countries while adhering to international standards. Value engineering techniques may also be applied to build competitive advantages within the region and in the international market place. The effects of Value engineering (VE) on industrial engineering will impact projects throughout the Caribbean. VE is a methodology that is known and accepted in the industrial sector. It is an organised process with a history of improving value and quality. The VE process identifies opportunities to remove unnecessary costs, while assuring that quality, reliability, performance and other critical factors meet or exceed customer’s expectations.

Keywords: Industrial engineering, Industrial engineers, Value engineering

1. Introduction
This paper seeks to examine the impact of industrial engineering on manufacturing industries within the Caribbean region. As the Industrial Revolution continues throughout Caribbean Community (CARICOM) countries, many projects will be undertaken, particularly in Trinidad and Tobago, where mega projects such as the ‘Water Front Project’ in Port of Spain, are under construction. These projects and the establishment of Caribbean Single Market and Economy (CSME) promise opportunities for industrial engineers, as well as the development of industrial engineering and value engineering practices in the region’s industrialisation thrust.

Industrialisation is defined as the development of large industries in a country or economic system. Industrial engineering was developed out of the process of industrialisation and incorporates disciplines such as, Production and Operations Management, Management Science, Project Management, Marketing Management and Value Analysis/Engineering/Management. These disciplines are applied to industries and organisations throughout CARICOM countries in their quest to produce and market high quality products and services for regional and international consumption. The methodologies utilised in industrial engineering to develop and grow businesses, are similarly employed by contractors, entrepreneurs and individuals who seek to create value in their respective industries.

Industrialisation in CARICOM countries took place as Caribbean governments sought to undertake economic development in the various islands. The central concern of postwar economic theory and policy in the Caribbean was how to get the economy to grow fast enough. It was anticipated that rapid growth would place the territories in a position to close the gap in real income per head between the region and the metropolitan countries of the North Atlantic; to create sufficient employment to absorb population increase and enough social and economic equality to ensure political stability.

It was expected that the regional economy would ultimately be better placed to reduce, if not eliminate
its traditional dependence on metropolitan areas for investment, technology, skills and business enterprise, hence the development of industrial engineering in the region and the requirement for management skills in an industrial Caribbean environment, in order to ensure that the countries remain on the path to long term sustainable growth and development.

2. Caribbean Industrialisation

The distinguished St. Lucian economist and Nobel Prize winner, Professor William Arthur Lewis (1950) contended that agriculture did not have the capacity to provide employment for the masses. While the population of the Caribbean islands continued to grow, the small size of the Caribbean land mass limited expansion of the agricultural sector. He stated further that continued absorption of surplus labour into the agricultural sector had the effect of reducing productivity levels on the plantations. Put differently, there was over-employment on the estates to the extent that the absence of a few workers would have had little or no effect on productivity levels.

Industry would draw the surplus labour away from the ‘plantation’ into the ‘modern industrial sector’ leading to a rise in average productivity in the agricultural sector as well as an increase in wages above subsistence levels for workers in that sector (Lewis, 1950). At the same time, entrepreneurs in the modern industrial sector would offer higher than subsistence wages to lure workers out of the traditional agricultural sector. This increased wage level would be possible because of the expected higher productivity of workers in this sector following the absorption of the surplus labour away from agriculture. It was also anticipated that these entrepreneurs would continue to reinvest their profits into the expansion of their businesses, as well as to seek new entrepreneurial activities.

In the post war era, sentiments were expressed in the region in favour of industrialisation. It was argued that the quality of life for most citizens who had known nothing else apart from agriculture had deteriorated sharply because of the low productivity levels on farms. Also, agriculture was very limited in its ability to absorb the growing population due to the small land mass. According to Lewis (1950), it was recommended industrialisation as a means of complementing agriculture.

2.1. Three Models of Industrialisation

Industrialisation in Caribbean countries especially during the decade of the 1960s was informed by one or a combination of theories that were gaining prominence during that period. Three models of industrialisation were seen as providing the key to the transformation of the plantation economies of the region. These were as follows:

The first one was the Foreign Direct Investment model. Lewis (1950) suggested that attempts should be made to lure foreign firms into setting up operations in the Caribbean islands, so that they could bring with them the necessary entrepreneurial skills, capital, technology and market links. This became the popular development strategy in the 1960s, especially in Jamaica, Trinidad and Tobago and Barbados.

The second one was the Import Substitution Investment model. Under this model, a country may attempt to conserve scarce foreign exchange by substituting goods previously imported with locally produced products, often in a protected atmosphere. In the context of Caribbean societies in the decade of the 1960s, this involved the use of trade barriers to discourage imports and the setting up of infant industries to undertake production of the substitute. Trade barriers included the use of discriminatory devices such as tariffs, quotas, negative lists and licencing, as well as overvalued exchange rates. The protected industry was expected to mature over time to the point where it could compete on an equal basis with its foreign competitors.

The third one was The Resource-Based Industrialisation. In this mode of investment, territories would seek to exploit the comparative advantage they possess in a particular resource by investing in products closely tied to the resource. In this way it was hoped that backward and/or forward linkages would be based on the abundance of the natural resource the territories already possess. An example of resource based industrialisation is the Pt. Lisas Industrial Estate in Trinidad and Tobago, which was established in 1980. The Estate houses a number of petrochemical companies and other downstream industries such as iron and steel smelting, and methonal production all of which were set up to utilise the cheap and abundant supply of natural gas with which Trinidad and Tobago is endowed.

2.2 Industrialisation by Invitation – The Second Industrialisation Thrust (1958-1974)

The third world in general possessed “unlimited supplies of labour from the traditional sector”. Lewis (1950) suggested that a marriage of
convenience between this cheap and plentiful labour, and the capital and technology of the developed world could produce the missing engine of growth and development in third world economies. This new economic strategy was later to be known as “Industrialisation by Invitation”.

2.2.1 The Period of Early Industrialisation
The Caribbean islands emerged from the nineteenth century primarily as agricultural economies in which sugar cane was the principal cash crop. This was to dictate several aspects of early industrialisation. In several of the islands steam-driven trains were used as transport for cane, and in the larger islands they were used as well for cargo and passenger transport. Heavy manpower resources were necessary to operate and maintain the engines, carriages and rails. Much of the early introduction to machinery was in connection with the steam engine as the prime motive. The processing or refining of the cane to produce sugar, itself created a well-equipped army of expert technicians and skilled tradesmen. This was the background of the early industrialisation in the West Indies up to the pre-World War II period.

2.2.2 Establishment of the Caribbean Community (CARICOM)
CARICOM was established in 1973 on the basis of a treaty. The original signatories to the Treaty were Prime Ministers Errol Barrow for Barbados, Forbes Burnham for Guyana, Michael Manley for Jamaica and Eric Williams for Trinidad and Tobago. The objectives of the Community were set out in Article 4 of the Treaty and were based on (i) economic integration through a common market and common trade policies; (ii) functional cooperation (pooling of resources and sharing of services in the area of human and social development; and (iii) coordination of foreign policies, presenting a united front in its relations with countries outside the grouping.

2.2.3 Establishment of the Caribbean Single Market and Economy (CSME)
The decision by Caricom in 1989 to establish the Caricom Single Market and Economy (CSME) was intended to deepen the integration movement among the region and to better respond to the challenges of globalisation. CSME involves trade liberalisation in goods and services among members. It provides for the free movement of capital, skilled labour and the freedom to establish business enterprise anywhere in the Community.

The aim of CSME is to provide the opportunity for greater cooperation among businesses, to improve and increase the quality and quantity of goods and services they produce, and to do so at better prices. This regional market promises to be an effective platform upon which workers in the construction sector could market their profession. CSME, therefore, presents opportunities for improvement of skills, economic status and standard of living for members of Caricom countries. Table 1 depicts the development of CARICOM and CSME.

With the emergency of CSME, many projects would be undertaken throughout the region and many of these projects would be funded by international agencies. In this context, Caricom countries would be required to operate within the global village and participate in international trade in order for the region to benefit from greater economic opportunities. Project management proposes a feasible approach to manage projects in industries and ensure that CSME remains viable. The management of projects would play an important role throughout the Caribbean region to ensure that projects are completed on time and within budget. According to the Project Management Body of Knowledge, Project Management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements.

3. Industrialisation and Industrial Engineering in CARICOM Countries
Industrialisation continues unabated throughout Caricom countries and many manual activities have been replaced by engineering capabilities, to eliminate waste on production lines, and increase production of goods and services. Industrial engineering utilises time and motion to increase productivity in the workplace. It examines work systems and maximises efficiency to produce products safely. For example, computerised industrial engineering machines are used to produce various types of items for industrial use; computerised robotic machines are used to drill holes and insert screws and bolts in large equipment for industrial use in various sectors of the economy. These processes contribute to efficiency in factories and manufacturing industries, as they lower the unit cost of production and enable firms to attract more customers.
Table 1. The Development of CARICOM and CSME

<table>
<thead>
<tr>
<th>Period of Existence</th>
<th>Name</th>
<th>Agreement/ Treaty</th>
<th>Main Objective</th>
<th>Signatories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>Caribbean Community and Common Market (CARICOM)</td>
<td>Dickenson Bay Agreement</td>
<td>Economic integration, foreign policy coordination and functional cooperation</td>
<td>Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts-Nevis, St. Lucia, St. Vincent and the Grenadines, Surinam and Trinidad and Tobago. Associated members are Anguilla, Bermuda, British Virgin Islands, the Cayman Island and Turks and Caicos Islands.</td>
</tr>
<tr>
<td>1981</td>
<td>Organisation of Eastern Caribbean States (OECS)</td>
<td>Treaty of Chaguaramas</td>
<td>Economic integration and cooperation in a range or areas such as external relations; human and social development; and defence</td>
<td>Antigua and Barbuda, Dominica, Grenada, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines. Associate members are Anguilla and the British Virgin Islands</td>
</tr>
<tr>
<td>2001</td>
<td>Caribbean Community including the Single Market and Economy (CSME)</td>
<td>Treaty of Basseterre</td>
<td>Further intensified economic integration, through a Single Market and Economy, foreign policy coordination and functional cooperation.</td>
<td>All member states except The Bahamas and Montserrat.</td>
</tr>
</tbody>
</table>

Throughout the Caribbean industrial estates are developed to increase production processes. In Trinidad and Tobago, some of these estates are (i) Philideco, in Pt. Lisas, Couva; (ii) O’Meara Industrial Estate in Arima, (iii) Diego Martin Industrial Estate in Diego Martin, and (iv) Trincity Industrial Estate in Trincity, where highly industrial processes are carried out in order to increase the production of quality goods.

The Government of Trinidad and Tobago also utilises industrial engineering techniques in its housing projects to build pre-fabricated houses at its La Horquetta, Maloney and Malabar Housing Development Projects. In this way, buildings are constructed at a faster rate and are generally more cost effective. Private contractors also use pre-fabricated concrete slabs to build houses at Santa Rose Heights in Arima, Trinidad.

Pre-fabricated concrete walls are mass produced, by industrial engineering techniques in factories such as Spancrete Limited, which is situated at the O’Meara Industrial Estate in Arima, Trinidad. Spancrete uses industrial engineering electronic equipment to mass produce concrete walls and roofs and other concrete structures for the construction sector. The company specialises in pre-fabricated building systems for the construction sector, and exports its building systems throughout the Caribbean. Environmental-friendly materials are used in the building system, which can withstand cyclonic winds, earthquakes, tremors, extreme climatic conditions, rotting and fire. The pre-fabricated building system is precision-engineered and cause components to lock easily and smoothly.

Another company contributing to the development of the industrial environment in Trinidad and Tobago, is the Caribbean Steel Mills Limited, where steel and steel products are produced for local, regional and international purposes, utilising industrial engineering methodologies. Caribbean Steel Mills Limited, pioneers in the steel industry in Trinidad and Tobago, is one of the most diversified manufacturing enterprises in the Caribbean. Its founder, Percival Bain, in 1970 recognised that there was a need in the industrial thrust for steel and steel-related products. The company began operations in 1972 with a Tube Mill equipped with Italian-made machinery for the production of structural, furniture and automotive tubing.

In the 1980s, the facilities of this mill were expanded to utilise radio frequency welding
technology for increased efficiency. A Profile Mill was installed, thereby widening the product range to include roofing sheets; factory cladding; ridging; purlins; composite floor decking door and window profiles. A mini Re-rolling Bar Mill which was installed in 1974 for the manufacturing of rounds, rebars and squares for the construction industry, was re-commissioned in 1992 to meet the expanding needs of the industry, locally and abroad. As a result of this restructuring, Caribbean Steel Mills was able to service the building, furniture and automotive industries. Recognising the need to maintain consistent product quality and in keeping with its export thrust, Caribbean Steel Mills re-engineered its activities, adopted a quality management system and obtained ISO certification in 1997.

Emanating from the industrialisation thrust in Caricom countries, professional bodies were established to provide oversight for the various industries operating in the Caribbean. One such organisation is the Trinidad and Tobago Manufacturing Association (TTMA). As Caribbean countries embark upon developmental projects to expand their economies, many projects will be undertaken. In executing these projects, various types of contracts will also be utilised for the procurement of goods and services. As a consequence, management skills must be applied by engineers and project managers, who are involved in the tendering and procurement processes of public and private contracts in CARICOM countries.

4. Contracts Utilised in Industries
Several different types of contracts are employed in the construction sector in CARICOM countries. The different types of contracts tell how the parties involved intend to measure the work done and consequently how payments are to be made. The central question facing senior managers and professionals in dealing with contracts revolves around the selection of a particular type of contract in a given situation. Three types of contracts commonly used in CARICOM countries are as follows:

- **Admeasurement Contracts** - An admeasurement contract is one in which all payments associated with measurement of work during the execution of the contract must be treated as interim payments and all the measurements as approximate measurements. A final measurement is to be carried out at the end of the works or at clearly identified and previously specified points in the execution of the works.

- **Lumps Sum Contracts** - A lump sum contract is one in which a tender or bid is for a sum specified, with no reference made to the items of work. An agreement can be entered into by which payment can be made in tranches based on agreed milestones for completed work.

- **Cost Plus Contracts** - A cost plus contract, also called reimbursement contract, may appear in several forms. The cost of the works (e.g., materials, machinery and equipment, labour and services) must be computed by adding up the various bills which represent payment by the contractor.

The acquisition of contracts in CARICOM countries will demand ethical behaviour on the part of engineers, consultants, contractors and other stakeholders, which will require ethical codes. Codes of practice, like specificiations and technical standards are guidelines of good practice based on scientific principles and the accumulation of wisdom drawn from wide experience. Suite (2001) states that codes of practice seek to govern the technical discharge of professional duties and how professionals carry out the works or the tasks at hand. A Code of Ethics seeks to govern the conduct or how people relate to other human beings with which they interact.

Professional organizations, such as the Association of Professional Engineers and the Architect Association, which are governed by Codes or Ethics are expected to play a pivotal role in the training of professionals in industrial engineering. These associations are self-regulating and set standards to govern the conduct of their members, as well as protect the public from unethical conduct of their members. Membership in these learned societies will provide a platform for professionals in industrial engineering to carry out their functions in a professional and ethical manner when dealing with other professionals, and the public in general. To this end, the procurement process in CARICOM countries demands scrutiny.

5. Public Procurement
Procurement has become an important and essential factor in the various industries in Caricom countries in the pursuit of industrial engineering and value engineering activities. Procurement is the acquisition of goods, works or services. Good procurement practices involve the selection of goods, works or services from a single or multiple sources to increase profitability and minimise cash flow problems by seeking out quality suppliers.

Public procurement is the process of acquiring property and services for public purposes. It involves
the utilisation of public money in a complexity of processes and choices in which - (i) needs are evaluated; (ii) products and services are identified; (iii) forms of delivery and methodology are identified; (iv) contractual arrangements to be entered into, and (v) works or services are performed.

Engineers, contractors and other stakeholders in industrial engineering could market their profession by bidding for contracts, using contract procurement systems, which have been developed overtime, from the Traditional Procurement Systems to the Build, Operate, Own, Transfer (BOOT) System. (Suite 1993) In so doing, these professionals can partner with their counterparts in CARICOM countries in the acquisition of contracts which should reflect uniformity in procurement processes, conformity to agreed principles and be consistent with best practices.

As professionals in industrial engineering seek to expand their careers regionally, knowledge of the various contract procurement systems will enhance their performance and add value to their profession. However, the success of any procurement system depends on a clear articulation and understanding of what the legal and regulatory framework seeks to achieve. The framework must reflect the required objectives. In the context of CARICOM countries, these objectives should include (i) greater public accountability; (ii) promotion of greater transparency in public procurement; (iii) consistency with and support of government policies; (iv) effective and efficient contract performance; and (v) value for money.

6. Value Methods in Managing Projects
Value resides in any sort of interest or appreciation of an object, event or state of affairs. Such appreciation involves feeling and ultimately desires tendencies or needs underlying the feeling (Pun, 2007). Customers will be satisfied if products and services provide them with value, consequently, organisations should create and maintain superior business performance, to improve their processes, products and services and so ensure a high rate of success. Value must reside in all industrial engineering processes and value engineering will ensure that the processes are undertaken efficiently.

Stakeholders expect value in return for their investments therefore, value analysis (VA); value engineering (VE) and value management (VM) become necessary in an industrial environment. Value Analysis is an orderly and creative method to increase the value of an item. This item can be a product, a system, a process, a procedure, a plan, a machine, equipment, tool, a service or a method of working.

6.1 Value Analysis
Value analysis identifies both the economic cost and use the performance value of the facility based on an initial project cost and total life cycle costs, as well as taking into consideration the safety and maintainability factors. Emphasis is also given to the social values based on the acceptability and adaptability to changing needs for the benefit of the society and human welfare. The value of an item is how well the item does its function by the cost of the item, i.e.: Value of an item = performance of its function/cost.

VA provides project managers with a powerful tool for maintaining quality standards while eliminating unnecessary costs and giving visibility for cost reduction efforts in the event of cost growth. Cost growth is one of the most difficult items to correct in industrial engineering. VA provides a “how to” answer to the question – “What can be done to reduce costs, yet maintain technical performance?” In addition to completing a project with technical excellence, and on time, the project must be completed within budget to be fully successful.

The VA methodology is most useful in the cost control aspect of industrial engineering activities, since it maintains quality while eliminating unnecessary costs, once it is used up-front in the conceptual stage. VA is used in the product planning, design, and support phases and its methodology provides insight into relationships of functions.

Value Analysis has been successfully used in all engineering disciplines and specialties and in organisations with the human and social services fields. The process is a structured sequential plan or strategy (Dell’Isola, 1997; Kelly et al., 2003). It consists of four (4) phases:

1) The Information Phase - The emphasis in this phase is on the creative thinking activities, that is, idea generation and evaluation of creative ideas. Therefore four tasks in the information phase include (i) Data Collection; (ii) Function identification; (iii) Cost analysis, and (iv) User reaction surveys.

2) The Speculation Phase - In this phase brainstorming takes place to answer questions such as (i) what else could do the job? (ii) in what other ways can each function be performed? All ideas are
recorded and shared.

3) The Evaluation and Analysis Phase - The brainstormed ideas are evaluated in terms of cost, feasibility and other relevant criteria. The key objective for this phase is to improve ideas. This phase is very important for those functions that have a high acceptance or a high cost.

4) The Implementation Phase - The objective of this phase is to sell the recommended improvements to stakeholders for the product resulting from the Value Analysis study. A proposal is prepared that demonstrates that the proposed changes are technically feasible and meet the management objectives. Substantial cost savings are also documented. Schedules and budgets for implementation need to be prepared as well as an assessment of the new skill and employee training that will be required.

6.2 Value Engineering

Value Engineering is a methodology that is known and accepted in the industrial sector. It is an organised process which improves value and quality. The VE process identifies opportunities to remove unnecessary costs while assuring that quality, reliability, performance, and other critical factors will meet or exceed the customer’s expectations in the industrial engineering environment.

The VE process embodies the function analysis discipline within a structured problem-solving methodology. Function analysis is the core of VE and is the basic discipline that provides the power that makes the methodology work.

A relationship between functions is obtained through use of a function analysis system technique (FAST) diagram. The diagram provides graphic two-dimensional presentation of the functions and identifies the basic function, secondary and supporting functions, higher-order functions and various other variations. It also assists in defining a critical path of functions starting from the initiating element through the supporting functions and basic function, to the higher-order function.

The FAST diagram does not provide the solution, but it defines the problems and shows the cost imbalances so that analysts can search for alternative solutions, which can reduce the costs of secondary functions or eliminate unnecessary functions and the costs associated with them.

6.3 Value Management

Value management is a process in which functional benefits of a project are made explicit and appraised consistent with a value system determined by the client. The client for the project will implicitly or explicitly establish a value system for the project. The definition of value is a relationship between time, cost and the variables that determine the quality the client seeks from the finished project. The main purpose of the value management is to make sure that a client receives the best value for money, ensuring higher quality and performance based on up-to-date technology for least cost.

Customers will be satisfied if products and services provide them with value. The effectiveness of value management relies upon the ability of managers to create a strategy that develops an organisation system consisting of (i) training, (ii) jobs, (iii) relationships, (iv) measurements, and (v) information systems that enable effective use of process management, which, when implemented enhances customer success through a supportive organisation culture and a focus on continuous improvement. The VM concept is useful for providing ever-improving value to customers and the improvement of overall company performance and capability.

The method of value management includes:

1) Development of Organisational Mission and Strategy – To communicate the organisation’s mission and strategy to all individuals in the organisation.

2) Training – For increased efficiency, quality, productivity and job satisfaction.

3) Job Design – To develop processes and people into a coherent system and transition to the flatter, more responsive form of management.

4) Interface Relations – To involve the customer in internal operations and to develop a ‘customer focus.’

5) Performance Measurement System – Performance metrics to – (i) support the attainment of the company’s objectives; (ii) link an individual’s decisions to the firm’s strategy; and (iii) track both the performance of the processes and the quality of the interactions.

6) Information Systems – To ensure that individuals and teams receive accurate information in a timely manner, because prompt, consistent provision of customer and performance data is necessary to enable effective response within the chain.

7) Process Management – Methodological and personnel practices that are used to manage processes throughout the value chain.

8) Organisation Culture – Culture is that set of values, beliefs and understanding that are shared by
the members of the organisation.
9) **Continuous Improvement** - An organisation’s efforts to continually strengthen the organisational culture and improve the performance of the supply chain will lead to greater customer success.
10) **Customer Success** – Meeting the needs of customers is a key to competitive success.

7. **Industrial Engineering and Value Method**

Industrial engineering (IE) is the branch of engineering that concerns the development, improvement and evaluation of integrated systems of people, knowledge, information, equipment, energy, material and processes and draws upon the principles and methods of engineering analysis and design, to specify, predict and evaluate the results to be obtained from such systems. Industrial engineers are specialists in the field and work to eliminate wastes of time, money, materials, energy and other resources. The name ‘industrial engineer’ has originally been associated with manufacturing but it has grown to encompass services and other industries which include Management Science, Operations Management, Project Management and Value Engineering (Heizer and Render, 2001).

The same tools and techniques employed by industrial engineers can be utilised by entrepreneurs and organisations to create sustainable business enterprises in Caricom countries while adhering to international standards. Management must: develop clear goals, systems, and motivation.

2) Continuous training can enhance the performance of individuals by enabling them to make better decisions, work as a team, and adapt to change, while also increasing efficiency, quality, productivity and job satisfaction.

3) Jobs may need to be redesigned to include a whole or more complete task as well as adequate authority and responsibility.

4) Involvement of the suppliers in the organisation’s operations is equally essential in value management.

5) Performance objectives and metrics provide focus for an individual or team’s effort, but performance feedback is needed to enable individuals to improve performance, processes and interactions.

6) Select customers and providers who are using electronic data interchange (EDI) and the internet to transfer order requirements, order status information, invoices and quality requirements between firms. These systems have reduced material and labour costs, increased the accuracy and speed of operations, as well as improved relations between firms.

7) The use of process management works both to strengthen the organisation culture and enhance continuous improvement in the supply chain.

8) Companies are increasingly relying upon the use of teams and are discovering numerous benefits, including the often-unrecognised benefit of the development of a supportive organisation culture.

9) Improvements can occur incrementally or through the use of “breakthroughs” or innovations, but for either to occur, the employees must be trained in the use of improvement techniques as well as in topics like problem solving, interpersonal skills, basic business and technical skills, team building and customer value.

8. **Conclusion**

The Industrial Revolution has impacted CARICOM countries to the extent that industrial engineering co-exists alongside other functional areas in industries throughout the region. Engineered building systems, such as pre-fabricated concrete walls and lightweight galvanized steel, adapt to Caricom countries varied and demanding climatic conditions.
Table 2. A structured framework for incorporating IE with VA/VE/VM practices

<table>
<thead>
<tr>
<th>Major Phases</th>
<th>Stages</th>
<th>Activities</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation and diagnostic phase</td>
<td>Identify value context with project sponsor and stakeholders</td>
<td>Hold briefing meeting with commissioning project sponsor. Define objectives of value study in relation to organisation’s VM policy. Identify and gain commitment from stakeholders. Agree on implementation with project sponsor.</td>
<td>The orientation and diagnostic phase is concerned with understanding the strategic context of the value study, its scope, timing, schedule and constraints. It is important during the early stages of this phase to gain stakeholder commitment and often this may require presentations or confidential interviews.</td>
</tr>
<tr>
<td>Define VM study scope</td>
<td>Determine study style</td>
<td>Agree scope and objectives of study with decision maker/project sponsor. Agree constraints for VM study – real and apparent. Determine the time scale for the VM study.</td>
<td>The exact nature of the study style will be determined and needs to be agreed with the project sponsor. This will determine the deliverables and the performance criteria for a successful study.</td>
</tr>
<tr>
<td>Gather comprehensive data for the VM study</td>
<td>Interview VM study participants. Collect user/customer attitudes Build data models</td>
<td></td>
<td>It is important that the value manager gathers all relevant information. This may include revisiting stakeholders and interviewing other potential participants if a team of records is to be used. If an independent VM study team is to be assembled it is important that skills are tailored to the problem at hand.</td>
</tr>
<tr>
<td>Identify and select team</td>
<td></td>
<td>Finalise VM team composition and agree with project sponsor</td>
<td></td>
</tr>
<tr>
<td>Study logistics</td>
<td>Brief participants with a meeting or with prepared documentation. Arrange venue</td>
<td></td>
<td>Briefing the VM study team is also important during this phase. This could be undertaken during confidential interviews, through a presentation.</td>
</tr>
<tr>
<td>Develop workshop agenda and process</td>
<td>Agree workshop phase agenda with project sponsor. Identify tools and techniques for use during workshop.</td>
<td></td>
<td></td>
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</tbody>
</table>

WORKSHOP PHASE

<table>
<thead>
<tr>
<th>Workshop Phase</th>
<th>Information sharing</th>
<th>Confirm value study objectives with VM team.</th>
<th>During this part of the workshop phase, the agenda and participants to the workshop will be introduced.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Back-to-basics; function analysis</td>
<td>Identify and classify functions</td>
<td>This is an important part of the workshop phase. It is central to value management and cannot be rushed. The experience of the authors is that it should not be omitted. Functional analysis diagrams will be constructed and other forms of analysis may also be used at this stage.</td>
</tr>
<tr>
<td></td>
<td>Create solutions and generate innovation.</td>
<td>Gather existing ideas. Create new ideas and options</td>
<td>Creating new ideas or options is almost always undertaken by brainstorming.</td>
</tr>
<tr>
<td></td>
<td>Evaluate possible solutions</td>
<td>Evaluate solutions in terms of: - Client acceptability - Functional suitability - Economic feasibility - Technical feasibility</td>
<td>It is also at this point that working groups are likely to be formed as part of the workshop phase, if they have not been operating in an earlier section.</td>
</tr>
<tr>
<td>Present and validate proposals</td>
<td>Work group presentations during final plenary. Presentation to senior management, if attending</td>
<td>Working groups can present to each other in a plenary session to cross-validate ideas/options for final agreement. Often a presentation to executives can be a good focusing mechanism at the end of a workshop to provide further broader inputs into team thinking.</td>
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<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
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<tr>
<td>Action planning for implementation</td>
<td>Develop implementation programme: - List activities to be carried out; - Identify time frames; - Appoint action plan coordinator; - Identify follow-up meeting/workshop one month after workshop complete.</td>
<td>The development of an action plan commences the process of implementation. Follow-up meetings can also be targeted, especially for presentation of the workshop report to the project sponsor/senior executives.</td>
<td></td>
</tr>
<tr>
<td>Prepare report</td>
<td>Prepare and issue draft report</td>
<td>This aspect can be helped if a recorder is employed to note the workshop proceedings</td>
<td></td>
</tr>
<tr>
<td>Present report and agree on final implementation</td>
<td>Present draft and oral report to project sponsor. Inform VM team of outcomes, dismiss or place on standby. Prepare and issue final report.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IMPLEMENTATION PHASE**

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Disseminate report</th>
<th>Disseminate report to: - Client project sponsor; - VM team - Other experts involved in VM study</th>
<th>Experience suggests that the post workshop phase needs further refinement to ensure that implementation of ideas/solutions continues. This could also include further, more detailed working up of options once the workshop has been completed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support implementation</td>
<td>Monitor status of actions; follow-up implementation and assist to correct deviations Obtain commitment implementation programme</td>
<td>Implementation workshop is very useful to continue the progress of implementation, or at a minimum a meeting with the project sponsor/senior executives to finalise the outcomes of a study. Often this is integrated with the presentation of the draft report.</td>
<td></td>
</tr>
<tr>
<td>Continuous improvement</td>
<td>Collate information on implementation targets and VM study performance Review strengths and weaknesses of VM study with project sponsor. Adjust VM study process and procedure.</td>
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</tr>
</tbody>
</table>

Advantages of these systems include minimum components, easy assembly, easy shipment, maximum strength, and durability. These systems are used by industrial engineers who are important players in numerous fields of industrial development that meet and surpass stakeholders’ expectations by providing value in deliverables.

Industrial engineering has contributed greatly to industrialisation process in Caricom countries, utilising pre-fabricated concrete walls and steel on a
large scale for the construction sector and for export throughout the Caribbean, Latin and South America. These products provide stable foundations, simple connections, simple relocation, easy extension and environmental-friendly solutions to the construction sector. This, as well as other industries, has provided employment for skilled and semi-skilled labourers, engineers and other professionals throughout Caricom countries, in keeping with the goals and objectives of CSME.

The Government of Trinidad and Tobago, in its Vision 20/20 initiative, has embarked upon a number of construction projects, chief among them is the Waterfront Development Project in Port of Spain, where a number of buildings are being constructed. At these building sites, industrial engineering takes centre stage, demonstrating the use of large industrial equipments and machinery utilising pre-fabricated concrete walls and steel produced at industrial estates throughout the country. Industrial engineers then collaborate and utilise industrial engineering and value engineering techniques to transform the country’s capital to developed country status.

From the aforementioned, it could be concluded that VA/VE/VM in industrial engineering would benefit Caricom countries in their current and future development initiatives. The future holds a bright future in CARICOM countries: It is anticipated that organisations must employ a structured framework to guide them along a process management path which would result in a methodology for continuous improvement of processes, products and services in order to enhance customer success.

VM must be implemented within organisations process management, as this contributes to the strengthening of the organisation’s culture with emphasis on continuous improvement. Moreover, managers must ensure that individuals and teams receive accurate information in a timely manner because prompt, consistent provision of customer and performance data is necessary to enable effective response within the chain.

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A Self-assessment Model for Evaluating Knowledge Management Performance

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Abstract This paper investigates the key attributes of knowledge management (KM) processes and performance metrics, and proposes an integrated paradigm that aligns the KM measures to attaining performance goals in organisations. It incorporated the main findings of a recent study that acquired the manufacturing practitioners’ views on the decision criteria on the integration of KM practices and performance measurement in Trinidad and Tobago. The empirical findings serve as a foundation for development of an integrated knowledge management (IKM) model and devise a scoring mechanism that assists organisations in self-assessments of their performance. It is expected that flexible adaptation of the model would help manufacturers to integrate KM practices and PM initiatives.

Keywords: Knowledge management, performance measurements, self-assessment, criteria

1. Introduction
Like other organisations, manufacturing enterprises are increasingly dependent on knowledge management (KM) practices to compete regardless of their size, nature and location. Lytras and Pouloudi (2003) describe KM as a holistic approach to management studies and practice. According to Jennex (2007), KM is the practice of selectively applying knowledge from previous experience of decision-making to current and future decision-making activities with the express purpose of improving the organisation’s effectiveness. The four core functions of KM are the creation, organisation/storage, sharing and use of knowledge with the purpose of improving upon the quality of products/services provided by an organisation.

Performance measurement (PM) is a process of quantifying the efficiency and effectiveness of actions that lead to performance in organisations (Pun and Lau, 2003; Neely, 1999). Quantitative measures (e.g. financial ratios, staff turnover, and number of customers’ complaints) are easy to be measured and managed. On the other hand, qualitative measures (e.g. quality, customer satisfaction, innovation, and leadership) are difficult to be measured, and are often at different levels of aggregation. In the KM context, the challenge is how to match and align performance measures with business strategy, structures and corporate culture, the type and number of measures to use, the balance between the merits and costs of introducing these measures, and how to deploy the measures so that the results are used and acted upon (del-Rey-Chamorro et al., 2003). Bose (2004) contends that the best and most logical approach to measuring the impact of KM on an organisation’s performance is to tie-in measurement of KM with the organisation’s overall PM systems.

This paper describes the development of an integrated KM model, incorporating the main findings of a recent KM/PM study of manufacturing practitioners based in Trinidad and Tobago. It explains the essential ingredients of the model, and relates them to the self-assessment and benchmarking practices in manufacturing enterprises. Accompanying the model, a results-
oriented scoring method is introduced.

2. Integrating KM/PM Initiatives
Nowadays, the need for organisations to adopt a culture of continual learning is rationalised by the fast pace at which the driving forces of change impact on organisational success. Innovation is driven by knowledge (du Plessis, 2007; Mason and Pauleen, 2003). Based on this notion, organisations are investing in their knowledge base. As organisations continue to learn, their knowledge base will continue to expand. This has led to the evolution of a stream of knowledge management.

The KM practices are divisible into a number of inter-connected activities that depend on the particular industry, the nature of the firm and the strategy it adopts (Wang and Ahmed, 2005). Broadly speaking, KM processes include knowledge identification, acquisition, codification, storage, dissemination, refinement, application and creation. Enabling such a balancing act requires changes in organisational culture, technologies, and techniques (Bose, 2004). McAdam and McCready (1999) propose the social constructionist model in which knowledge is linked to social and learning processes. Earl (2001) further identifies three KM strategies comprising 1) Technocratic schools from an IT perspective; 2) Economic schools from a revenue perspective, and 3) Behavioural schools from a social perspective.

Recent literature has identified various principles, criteria and attributes in connection with KM and performance measures. Many practitioners and researchers have postulated different models, frameworks and approaches pertinent to KM, PM and their integration (del-Rey-Chamorro et al., 2003; Malhotra, 2005; Sasson and Douglas, 2006). Although most of these models stood by themselves empirically and/or theoretically, they have constraints borne with their own application domains. In an attempt to develop a holistic paradigm, an integrated KM model is proposed.

Recent studies (e.g. see Malhotra, 2005; Marqués and Garrigós Simón, 2006) suggest PM facilitates execution of business and KM strategies by 1) signalling what to measure; 2) determining appropriate ways to measure; and 3) fixing accountability for performance on the measures. Identification of KM determinants and performance criteria provides the basis for achieving the intended performance ends. Based largely on Pun and Lau (2003)’s study, a set of key attributes relating to performance measures and KM practices is identified as in Table 1.

<table>
<thead>
<tr>
<th>Key attributes/criteria</th>
<th>Sub-criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Senior Management Leadership (SL)</strong></td>
<td>1.2 Corporate mission, vision and values (CMV)</td>
</tr>
<tr>
<td></td>
<td>1.3 Management involvement (MIN)</td>
</tr>
<tr>
<td></td>
<td>1.4 Management commitment (MAC)</td>
</tr>
<tr>
<td></td>
<td>1.5 Strategy/policy development (SPD)</td>
</tr>
<tr>
<td><strong>2. KM Processes (KP)</strong></td>
<td>2.1 Identification and acquisition of knowledge (IAK)</td>
</tr>
<tr>
<td></td>
<td>2.2 Codification and storage of knowledge (CSK)</td>
</tr>
<tr>
<td></td>
<td>2.3 Dissemination and refinement of knowledge (DRK)</td>
</tr>
<tr>
<td></td>
<td>2.4 Application and creation of knowledge (ACK)</td>
</tr>
<tr>
<td><strong>3. People Development (PD)</strong></td>
<td>3.1 People education and training (PET)</td>
</tr>
<tr>
<td></td>
<td>3.2 People well-being and satisfaction (PWS)</td>
</tr>
<tr>
<td></td>
<td>3.3 People involvement (PIN)</td>
</tr>
<tr>
<td></td>
<td>3.4 People empowerment (PEM)</td>
</tr>
<tr>
<td><strong>4. Continuous Improvement (CI)</strong></td>
<td>4.1 Learning culture (LEC)</td>
</tr>
<tr>
<td></td>
<td>4.2 Continuous innovation (COI)</td>
</tr>
<tr>
<td></td>
<td>4.3 Review of strategy/policy (RSP)</td>
</tr>
<tr>
<td></td>
<td>4.4 Balancing/satisfying needs (BSN)</td>
</tr>
<tr>
<td><strong>5. Results Orientation (RO)</strong></td>
<td>5.1 Customer focus (CUF)</td>
</tr>
<tr>
<td></td>
<td>5.2 Financial results (FIR)</td>
</tr>
<tr>
<td></td>
<td>5.3 Non-financial results (NFR)</td>
</tr>
<tr>
<td></td>
<td>5.4 Social responsibilities (SOR)</td>
</tr>
</tbody>
</table>
These attributes comprise five criteria, including 1) senior management leadership, 2) KM processes, 3) people development, 4) continuous improvement, and 5) results orientation. Each criterion is composed of four sub-criteria, totalling twenty sub-criteria.

Organisations need to determine the speed and right data to communicate performance targets. Moreover, performance measures must be implemented at the unit, team, and individual levels, and must also fix accountabilities for performance. Specific outcomes and behaviour can then be specified and linked to consequences. PM systems must be designed to drive KM practices in organisations (Malhotra, 2005). The integration of KM and performance measures is an end that plays a communication role to motivate staff, and improve control and accountability mechanisms in organisations (Yiu and Sankat, 2007).

3. Conduct of an AHP Study
3.1. Purposes
The alignment with performance measures and KM practices in organisations involved decisions with certain fuzziness. This would become more complicated as the number of decision criteria increased. The analytic hierarchy process (AHP) methodology as devised by Saaty (1994, 2000) is used as a management tool in structuring fuzzy and complex problems. It allows the structuring of complex decision scenarios in a systematic way and to assess the possible courses of action (Saaty, 2000). The methodology has received a wider attention in various fields of applications related to performance measures in manufacturing (e.g. see Yurdakul, 2002; Yang and Chen, 2006; Shahin and Ali Mahbod, 2007).

An AHP-based study was recently conducted to acquire the views of invited evaluators (i.e. senior executives and representatives) on various KM/PM criteria and sub-criteria in Trinidad and Tobago (Yiu and Sankat, 2007). It aimed to reaffirm the evaluators’ intent regarding 1) the prioritisation of the KM/PM criteria and 2) the integration of KM practices with performance measures.

3.2. The Methodology
AHP uses a qualitative method to decompose an unstructured problem into a systematic decision hierarchy. A hierarchy is an abstraction about the structure of the system, consisting of several levels representing the decomposition of the overall objective to a set of clusters, sub-clusters, and then down to the final level (Saaty, 1994, 2000). It employs a pair-wise comparison to execute the consistency test to validate the consistency of responses. The strength of AHP lies in its ability to mimic the management judgement about the importance that would be attached to different influential factors and to structure a complex and multi-attribute system matrix.

The conduct of AHP-based study would go through four steps, involving: 1) structuring of a decision problem, 2) measurement and data collection, 3) computation of normalised weights, and 4) determination of synthesis-finding solution to the problem (Saaty, 1994, 2000). The study was addressed to a targeted group of participants rather than a more conventional test of a few preconceived hypotheses in a larger number of respondents. Figure 1 shows an analytical framework that is used to facilitate the personal interviews with participants or evaluators from invited companies. The computations and analysis of interview findings were made using the computer software, Expert Choice (2002).

4. Findings and Analysis
4.1. Response Rates and Company Profile
A quota sampling method based on four categories of industry sectors was adopted. A cluster of eight organisations was selected from each of four industry sectors, including 1) energy-based manufacturing, 2) non-energy manufacturing, 3) manufacturing services organisations and 4) other related sectors. All selected companies were either of local ownership or joint ownership with regional or foreign investments.

In total, 15 interviews were successfully conducted with 32 selected organisations, yielding a 46.9 percent of response rate. Three participants (i.e. 20%) are senior executives (e.g. directors, senior consultants) of their organisations and the others include three production/operations managers (i.e. 20%), two analysts (i.e. 13.3%), three officers (i.e. 20%) and four engineers (i.e. 26.7%). These personnel are responsible for and/or involved in performance measures and KM processes in their organisations. Their views provide a wide spectrum of experience and expertise across various industry sectors.

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4.2. Priorities among KM/PM Criteria and Sub-criteria

Individual evaluators (i.e. the company participants) were asked to make a pair-wise comparison judgement among decision criteria and its sub-elements using the AHP methodology. The pair-wise comparison data were organised in the form of a matrix and were summarised on the basis of Saaty’s (1994) eigenvector procedure. The absolute weights were then used to determine the relative priorities of these criteria and sub-criteria. Global priorities (i.e. relative to the goal) were generated with the aid of Expert Choice software.

The eigenvector method yields a natural measure for inconsistency. The consistency ratios (CRs) for various decision matrices were computed, ranging from 0.02 to 0.08, which fell within the acceptable level of 0.10 as recommended by Saaty (1994). This showed that evaluators have a positive view and assigned their weights consistently on the examination of the priorities of decision criteria on evaluating the integration of PM and KM practices in their respective organisations.

**Level-1 Criteria**

In examining the global weights of criteria in level 1 (see Table 2), evaluators considered senior management leadership (i.e. with normalised weight, SL = 0.287) to be the leading criterion followed by results orientation (i.e. RO = 0.245) and people development (i.e. PD = 0.217).

Results show that the senior management leadership and people development could drive both performance measures and KM practices in their companies. Senior management would set directions and expectation for employees to achieve...
performance, and cultivate an empowered organisational environment that facilitates KM practices. This encourages people development at various levels to release their potentials for organisation’s benefit. Evaluators also stressed the results orientation (RO) aspects that would promote customer focus and financial results for performance improvement. Nevertheless, many evaluators considered the KM processes (KP) criterion as less critical when compared to the other four criteria.

Table 2. Global weights of judgements on KM/PM Criteria

<table>
<thead>
<tr>
<th>Level 1: KM/PM Criteria</th>
<th>Global weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Senior management leadership (SL)</td>
<td>0.287</td>
</tr>
<tr>
<td>2. KM Processes (KP)</td>
<td>0.108</td>
</tr>
<tr>
<td>3. People development (PD)</td>
<td>0.217</td>
</tr>
<tr>
<td>4. Continuous improvement (CI)</td>
<td>0.143</td>
</tr>
<tr>
<td>5. Results orientation (RM)</td>
<td>0.245</td>
</tr>
</tbody>
</table>

Remarks: Priority score: i.e. 0.000 = the least significant; 1.000 = the most significant

Level-2 Sub-criteria

Table 3 shows the global priorities relative to the goal of integrating performance measures and KM practices. The five top sub-criteria with respect to the global priorities in combined judgements were Management Involvement (MIN = 0.099), Customer Focus (CUF = 0.083), Management Commitment (MAC = 0.82), Financial Results (FIR = 0.076), and People Education and Training (PET = 0.073).

Besides, the AHP results showed that evaluator groups considered the reliance of codification/storage of knowledge (i.e. CSK = 0.030), identification/acquisition of knowledge (i.e. IAK = 0.026), and dissemination/refinement of knowledge (i.e. DRK = 0.015) as generally less dominating sub-criteria when compared to others in promoting the PM/KM integration in their respective organisations.

Table 3. Global weights of judgements on KM/PM Sub-criteria

<table>
<thead>
<tr>
<th>Level 2: KM/PM Sub-Criteria</th>
<th>Global weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Corporate mission, vision and values (CMV)</td>
<td>0.047</td>
</tr>
<tr>
<td>1.2 Management involvement (MIN)</td>
<td><strong>0.099</strong></td>
</tr>
<tr>
<td>1.3 Management commitment (MAC)</td>
<td><strong>0.082</strong></td>
</tr>
<tr>
<td>1.4 Strategy/policy development (SPD)</td>
<td>0.059</td>
</tr>
<tr>
<td>2.1 Identification/acquisition of knowledge (IAK)</td>
<td>0.026</td>
</tr>
<tr>
<td>2.2 Codification/storage of knowledge (CSK)</td>
<td>0.015</td>
</tr>
<tr>
<td>2.3 Dissemination/refinement of knowledge (DRK)</td>
<td>0.030</td>
</tr>
<tr>
<td>2.4 Application and creation of knowledge (ACK)</td>
<td>0.037</td>
</tr>
<tr>
<td>3.1 People education and training (PET)</td>
<td><strong>0.073</strong></td>
</tr>
<tr>
<td>3.2 People well-being and satisfaction (PWS)</td>
<td>0.037</td>
</tr>
<tr>
<td>3.3 People involvement (PIN)</td>
<td>0.044</td>
</tr>
<tr>
<td>3.4 People empowerment (PEM)</td>
<td>0.062</td>
</tr>
<tr>
<td>4.1 Learning culture (LEC)</td>
<td>0.035</td>
</tr>
<tr>
<td>4.2 Continuous innovation (COI)</td>
<td>0.035</td>
</tr>
<tr>
<td>4.3 Review of strategy/policy (RSP)</td>
<td>0.030</td>
</tr>
<tr>
<td>4.4 Balancing stakeholders’ needs (BSN)</td>
<td>0.043</td>
</tr>
<tr>
<td>5.1 Customer focus (CUF)</td>
<td><strong>0.083</strong></td>
</tr>
<tr>
<td>5.2 Financial results (FIR)</td>
<td><strong>0.076</strong></td>
</tr>
<tr>
<td>5.3 Non-financial results (NFR)</td>
<td>0.044</td>
</tr>
<tr>
<td>5.4 Social responsibilities (SOR)</td>
<td>0.042</td>
</tr>
</tbody>
</table>

Remarks: Priority score: i.e. 0.000 = the least significant; 1.000 = the most significant
5. Development of an IKM Model

5.1 Constructs and components of the model
The AHP analysis determined the relative importance of key criteria and sub-criteria for successful integration of PM/KM practices. Some criteria are essentially directed towards the performance measures internally, while others require the performance to be assessed from the perspective of external stakeholders. Senior Management Leadership is the driver of the KM/PM integration that leads to the sustained pursuit of customer value and improvement in performance. The integration of KM/PM efforts rests on KM processes, people development and continuous improvement to meet the performance requirements. The results-oriented measures of progress provide a basis for channelling actions to attain corporate performance goals. Based on the AHP findings compiled from industry practitioners, an integrated KM model was proposed. It comprises five categories of criteria, including 1) Senior Management Leadership, 2) KM Processes, 3) People Development, 4) Continuous Improvement, and 5) Results Orientation.

5.2 Characteristics and features of the model
A reliable self-assessment tool for performance should satisfy two cardinal conditions (Pun and Lau, 2003). First, it should measure what it is supposed to measure, in this case, measuring all dimensions of business that are deemed to have impact on overall organisational performance. Second, it should be able to measure them correctly, in this case providing a measurement score that is credible and comparable within industry or across industries. In order to satisfy these two conditions, the IKM model employs the guiding principles embodied with the business excellence model (e.g. European Quality Award) under which the integration of KM practices and performance measures can proceed.

An attempt was made to determine the scoring mechanism based on the normalised weightings of the criteria and sub-criteria in the AHP analysis. Table 4 shows that the IKM model has twenty sub-criteria under five categories of KM/PM criteria, with a total score of 1,000 points.

### Table 4. Self-assessment scoring list of KM performance

<table>
<thead>
<tr>
<th>Categories/Items</th>
<th>Point Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Senior Management Leadership (SL)</td>
<td>290</td>
</tr>
<tr>
<td>1.1 Corporate Mission, Vision and Values (CMV)</td>
<td>50</td>
</tr>
<tr>
<td>1.2 Management Involvement (MIN)</td>
<td>100</td>
</tr>
<tr>
<td>1.3 Management Commitment (MAC)</td>
<td>80</td>
</tr>
<tr>
<td>1.4 Strategy/Policy Development (SPD)</td>
<td>60</td>
</tr>
<tr>
<td>2 KM Processes (KP)</td>
<td>110</td>
</tr>
<tr>
<td>2.1 Identification/Acquisition of Knowledge (IAK)</td>
<td>20</td>
</tr>
<tr>
<td>2.2 Codification/Storage of Knowledge (CSK)</td>
<td>30</td>
</tr>
<tr>
<td>2.3 Dissemination/Refinement of Knowledge (DRK)</td>
<td>20</td>
</tr>
<tr>
<td>2.4 Application/Creation of Knowledge (ACK)</td>
<td>40</td>
</tr>
<tr>
<td>3 People Development (PD)</td>
<td>210</td>
</tr>
<tr>
<td>3.1 People Education and Training (PET)</td>
<td>70</td>
</tr>
<tr>
<td>3.2 People Well-being/Satisfaction (PWS)</td>
<td>40</td>
</tr>
<tr>
<td>3.3 People Involvement (PIN)</td>
<td>40</td>
</tr>
<tr>
<td>3.4 People Empowerment (PEM)</td>
<td>60</td>
</tr>
<tr>
<td>4 Continuous Improvement (CI)</td>
<td>140</td>
</tr>
<tr>
<td>4.1 Learning Culture (LEC)</td>
<td>35</td>
</tr>
<tr>
<td>4.2 Continuous Innovation (COI)</td>
<td>35</td>
</tr>
<tr>
<td>4.3 Review of Strategy/Policy (RSP)</td>
<td>30</td>
</tr>
<tr>
<td>4.4 Balancing Stakeholders’ Needs (BSN)</td>
<td>40</td>
</tr>
<tr>
<td>5 Results Orientation (RO)</td>
<td>250</td>
</tr>
<tr>
<td>5.1 Customer Focus (CUF)</td>
<td>85</td>
</tr>
<tr>
<td>5.2 Financial Results (FIR)</td>
<td>80</td>
</tr>
<tr>
<td>5.3 Non-financial Results (NFR)</td>
<td>45</td>
</tr>
<tr>
<td>5.4 Social Responsibilities (SOR)</td>
<td>40</td>
</tr>
<tr>
<td>Total:</td>
<td>1,000</td>
</tr>
</tbody>
</table>
The maximum score for respective criterion ranged from 110 to 290 points for respective sub-criterion from 20 to 100. The scoring mechanism serves as a foundation for the self-assessment IKM paradigm. Figure 2 shows a diagrammatic representation of the construct of the model. The first four categories of criteria (i.e. SL, KP, PD and CI) are enablers that address the approach and deployment of, while the last RO category assesses the results of, PM/KM integration.

5.3 Self-assessment instruments and guidelines
The KM/PM criteria are designed objectively for self-assessment of organisational performance on an ongoing basis. They help users to set the predetermined evaluation requirements and the deployment of organisational resources. Self-assessment can allow users to examine dynamic relationships amongst criteria and performance. The results can serve as a communications means and as a basis for deploying consistent overall performance requirements (Pun, 2002).

An organisation could furnish its performance information using some self-assessment tools or instruments. One common tool is the scoring matrix that contains a set of checklist-type questionnaire for the purposes of self-assessment and benchmarking (EFQM, 2000, 2007). For each sub-section of individual criteria of enablers, measuring items are developed to assess the presence of approaches and the extent of deployment; and for the sub-sections of results orientation, the extent of positive trend in the results is assessed. Senior management is responsible for the design and revision of the matrix, taking into consideration the inputs from employees, customers, and the public.

Since most decision criteria are non-prescriptive and cannot be directly measured, they are translated into a set of performance indicators that are then converted into measuring items. These items are modelled to identify the focal areas of KM performance measures. A standard self-assessment questionnaire must be used on a regular basis, so that organisations can monitor progress over time and anticipate changes. Nevertheless, if any adjustments need to be made to the standard questionnaire that was designed and currently in use, these adjustments must be kept to a reasonable level. It is because any radical changes may jeopardise the reliability of the model and the chance of getting meaningful and comparable results (Lee and Quazi, 2001). The self-assessment results could serve as a communications means and as a basis for deploying consistent performance requirements (Pun, 2002).

6. Conclusion
There is constant pressure on management to improve organisational effectiveness. The IKM model adopts the guiding principles embodied with the Business Excellence Models and stresses the results-oriented assessments on five categories of criteria. The point values for these criteria were generated collectively from the practitioners’ perspectives using the AHP analysis. The model can provide organisations with a set of criteria that guide KM practices and manage performance measures.

The self-assessments obtained would constitute a base for internal benchmarking and external comparison of performance, and create conditions conducive to continuous performance improvements. It is anticipated that flexible adaptation of the model with its scoring method would provide practitioners with pragmatic understanding about integrating KM practices and PM initiatives.

7. References


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A 14-Step Strategy of HACCP System Implementation in Snack Food Manufacturing

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Abstract: Food safety is a significant part of the manufacture of any food product. The use of the International Standard of Hazard Analysis Critical Control Points (HACCP) is to identify preventive steps to reduce hazards at each Critical Control Point. HACCP is widely accepted as a food safety management system. This study presents an implementation case of the HACCP system for a snack food manufacturer in Trinidad and Tobago. The company has been implementing HACCP on a trial basis for one product, with an intention to extend it to other product lines. A 14-step implementation strategy was developed. The trial led to good manufacturing practices and improvements in personal hygiene and sanitation. Results showed that reductions of the Total Non-Conformances were achieved by 54.6% and the Total Customer Complaints by 42.3%, respectively for the studied company. Future research could investigate a holistic paradigm that aligns HACCP measures for attaining safety performance goals in the snack industry sector.

Keywords: Hazards, Critical control Points, HACCP, Food Safety

1. Introduction

With many changes in food production and consumption, the risk of food borne illnesses is continuously increasing. In response to these changes and threats, countries are becoming more stringent in their surveillance and regulations in an effort to protect consumers. Almost every country around the world has been focusing on food safety in intense and multifaceted ways (Pun and Bhairo-Beekhoo, 2008). The Hazard Analysis Critical Control Points (HACCP) system and ISO 22000:2005 are examples of International Food Safety Quality Management systems that have been introduced to assist in improving operations of stakeholders along the food chain. HACCP is an umbrella term used to describe various activities that affect food safety. It concentrates prevention strategies on known hazards and the risk of them occurring at specific points in the food chain.

In Trinidad and Tobago, the importance of controlling food poisoning outbreaks has been increasingly recognised owing to the increasing number of meals consumed outside the home, in parallel with the ever-expanding range of snacks, pre-prepared meals, and meal substitutes. Nevertheless, there has been a lack of public awareness to the seriousness of, and no authoritative body and regulations to which the public can address any issues or cases of food poisoning.

Snacks are classified as ‘impulse foods’. This basically means that these items are not usually included in a grocery list, but are bought primarily by sight in the supermarket, pharmacy and any other place where people shop. Tortilla chips, potato chips, nuts and cheese snacks are altogether called the ‘salty snack’ category. This paper investigates into the HACCP implementation in a leading snacks manufacturer in Trinidad and Tobago. It describes the methodology (i.e. How?) and the reasons (i.e. Why?), whereby the HACCP system is implemented in the company. The customer complaint and non-conformance data was analyzed and the root causes for the hazards were identified. The paper then discusses the findings and achievements of the...
HACCP implementation with respect to the study objectives. The potential applications to other product lines are also discussed.

2. Determinants of Safety Practices in Snack Industry Sector

According to the World Health Organisation (WHO), disease can either be food, air or water borne. As such, food borne disease is any disease of an infectious or toxic nature caused by, or thought to be caused by the consumption of food or water. It can either be of a microbiological, chemical or physical nature (Griffith, 2006a). Food safety, synonymous with food hygiene, embraces anything in processing, preparation or handling of food to ensure that it is safe to eat (Griffith, 2006b). The responsibility of food safety encompasses various food sectors of people, including producers and processors of food, governments and the consumers themselves (Pun and Bhairo-Beekhoo, 2008). Hazards in the process of manufacturing would constitute significant threats to the consumers because they could be passed on through the company’s operations from receipt of raw material and ingredients to the distribution of packaged products (FAO, 1998).

Hazard analysis can be defined as the process of collecting and evaluating information on hazards and conditions leading to their presence in foods to decide which are significant for that food’s safety (FAO, 1998). This is a two-step process, comprising hazard identification and hazard evaluation. Hazard identification involves analyzing each raw material, production process and consumer use, and identifying appropriate control measures to reduce or eliminate potential hazards. The identification requires systematic evaluation of raw materials used in the food and the steps identified in the production flow diagram. Hazard evaluation is the process of reviewing each hazard that is identified to determine the severity of the health risk to the consumer and the probability of occurrence (see Figure 1). This is a logical continuation of product description and flow chart construction.

Businesses must identify the potential hazards likely to be associated with its operations and develop systems to control. The contamination of a food source whether accidental or deliberate can have far reaching consequences. This is especially so in a society where increasing responsibility for the safety of the food that is eaten is entrusted in food processors, the retail sector and food services (Manning and Baines, 2004). The onus is on the individual food business to take positive action to ensure that food produced is safe and wholesome. This involves two key elements. They are, firstly, risk assessment coupled with hazard analysis; and secondly, training in food hygiene is absolutely critical, particularly for supervisors and managers.

Figure 1: Hazards Analysis

A critical control point (CCP) is a location, procedure or process in a food production operation where chemical, microbiological or physical hazard can be minimized if proper control is maintained at that point. In food hygiene, control points and CCP are related to the HACCP system (Amjadi and Hussain, 2005). The application of HACCP is not limited to food manufactured and processed by medium to large-scale operations but may also be applicable to smaller operations where safety of foods is of critical importance. HACCP is the system of choice in the management of food safety, and is compatible with that of quality management systems, such as ISO 9000 series (Manning et al., 2006; Nguyen et al., 2004).

HACCP is the system of choice in the management of food safety, and is compatible with that of quality management systems, such as ISO 9000 series (Manning et al., 2006; Nguyen et al., 2004). Adopting HACCP assists companies to comply with legislation, supports due diligence and fulfills customer requirements for a food and safety management system. The objective of the HACCP system is to guarantee food safety by implementation of a quality system, which covers the complete food production chain, from the primary sector up to the final consuming of the product. Food manufacturers are not only responsible for the Good Manufacturing Practices within their respective organisations, but also address the possible hazards (Arnjadi and Hussain, 2005). For example, if there is a possibility...
that the raw materials are exposed to certain hazards, a manufacturer is responsible to check if and how the supplier of the raw materials controls these hazards. Besides, the manufacturer must supply the consumer with sufficient information about handling of the product to avoid hazards, which can occur during cooking and/or storage of the product.

HACCP is a proactive approach to building food safety into one’s food production or preparation process that depends on the common sense application of both scientific and technical methods in the plant (FAO, 1998; Nathai-Balkissoon and Arumugadasan, 2004). An efficient and accurate record keeping within HACCP is essential. This provides the manufacturer with confidence that their product is safe and allows auditors to do their job. Documentation includes details of the component raw materials, the processing and the requirements of final products. Additionally, details of the HACCP plan, staff training, audit and verification details are needed. Nevertheless, people’s resistance to change is the main obstacle to the HACCP implementation. Other barriers include inadequate support and facilities such as, the layout, space limitations, and poor design facility (Pun and Bhairo-Beekhoo, 2008).

3. A 14-step Strategy Model of HACCP System Implementation

Many agencies, practitioners and researchers have suggested different strategies, models and frameworks to implement HACCP in food industry sectors. Some of them are adopting a generic approach, while others are company or industry specific to a particular environmental or application. For instance, the Canadian Food Inspection Agency developed a food safety enhancement programme in 1993 (CFIA, 1993). The Food and Agriculture Organisation of the United Nations published a training manual on food hygiene and HACCP systems in 1998 (FAO, 1998). Woolworths instituted a vendor quality management standard in 1995. The standard required: pre-requisites procedures – cleaning operations, good manufacturing practice (GMP), training (hygiene awareness), recall procedure, pest control procedures, factory inspection prior to commencement of operations; and the development of a HACCP plan following a 12-step process (Khatri and Collins, 2007). Nathai-Balkissoon and Arumugadasan (2004) also advocated a 12-step HACCP programme that was composed of five preliminary steps and seven basic HACCP principles for food plant operations.

A digest of the related literature helps develop a practical model for facilitating HACCP implementation. The authors have proposed a 14-step strategy model of HACCP system implementation. However, two basic pre-requisites are assumed. The first is that the user organisations are well versed in the food safety needs and requirements for their business operations. Second, they are reasonably aware of the HACCP principles. A schematic presentation of the strategy model is given in Figure 2. The sequence of individual steps may be altered with respect to varied business operations and nature of organisations.

In order to demonstrate the proposed strategy model, a trial implementation in a food manufacturer, HSL Company, in Trinidad and Tobago was used. The Company produces a large number of snacks (such as extruded corn-based puffs, corn-based tortillaz chips, potato chips and nut products) for sales in the Caribbean and aboard. In 2007, the trial implementation of HACCP was undertaken in one of its product lines (i.e. Tortillaz Chips). The 14 steps of the HACCP system implementation are elaborated below:

3.1 Commitment to Food Safety Improvements

Top management is the main driver of safety efforts throughout the implementation process (Pun and Hui, 2002). Management leadership and commitment can bring about corporate-wide safety initiatives and management practices in compliance with the HACCP principles and related safety standards. Having a clear corporate vision and mission for HACCP system implementation is essential, so that people can understand management’s commitment and expectation. The management should nurture a safety culture, develop the objectives, goals and policy, define the safety responsibilities, and delegate authorities and assign resources to where appropriate for the preparation and execution of changes and improvements across the entire organisation.

3.2 Formation of a HACCP Team

In 2006, a multi-disciplinary HACCP team was formed at HSL. Members from a wide range of expertise were selected so as to ensure a company-wide participation and implementation. Their responsibilities include: 1) ensuring the Food Safety Management System requirements are established, implemented and maintained in accordance with the HACCP System and 2) reporting on the performance of the Food Safety Management System to
Step 1: Commitment to Food Safety Improvements

Step 2: Formation of a HACCP Team

Step 3: Conduct of Gap Analysis
Step 4: Description of the Products
Step 5: Construction of Flow Diagrams

Step 6: Identification of Hazards and Control Measures
Step 7: Determination of Microbiological Hazards
Step 8: Determination of Physical and Chemical Hazards

Step 9: Conduct of Risk Assessment

Step 10: Design of Critical Control Points and Target Levels

Step 11: Monitoring of Safety Measures
Step 12: Planning for Corrective/Improvement Actions
Step 13: Verification of Process and Documentation

Step 14: Reinforce Continuous Performance Improvements with HACCP

Figure 2: A 14-step Strategy Model for HACCP System Implementation

3.3 Conduct of Gap Analysis
A thorough Gap analysis examined objectively the current Quality Management System in place and related operations to the requirements of the HACCP system (such as material handling and storage, maintenance and equipment performance, personnel training, sanitation and personal hygiene, and health and safety recall procedures). The results helped the company to compile a list of areas for improvement and develop action plans and deadlines. Several tasks could be completed simultaneously by team members or assigned to other members of staff with respect to the assigned priorities and responsibilities.

3.4 Description of the products
Begun with thorough understanding of the selected product, the HACCP Team should know the composition and processing of the food and the severity and risk of any hazards. The description of the product requires knowledge of 1) product characteristics and composition, 2) structure, 3) processing, 4) packaging, 5) storage and distribution conditions, 6) required shelf life, and 7) instructions for use. With the implementation of HACCP system, more details were required on microbiological characteristics, nutritional values, chemical and management for review, and as a basis for continual improvement. For this initiative at HSL, the Production Manager has been appointed as the Coordinator/Leader for the establishment and implementation of the Food Safety Management System. Other members were the Operations Manager, the Quality Assurance Manager, a Quality Systems Technician, a Production Supervisor, and a Warehouse Supervisor.
physical properties, and packaging labeling information.

3.5 Construction of Flow Diagram
Team members constructed the flow diagram to cover various steps in the operation for easy identification of routes of potential contamination and controls. Process flow diagrams include: 1) The sequence and interaction of various steps in the operation, 2) Any outsourced processes and subcontracted work, 3) Where raw material, ingredients and intermediate products enter the flow, 4) Where reworking and recycling take place, and 5) Where end products, intermediate products, by-products and waste would be removed. The objective was to visualize the flow of the production process and to make the process transparent. Once the flow diagram has been produced, it needed to be checked for accuracy. Variations in work practices often occur when different line supervisors are in control. This check involved members of the HACCP Team at different times with different shifts. The completed checklists form a record of the assessment and provided a baseline for the assessment of change.

3.6 Identification of Hazards and Control Measures
The hazard analysis consists of 1) listing all the hazards that can be present, 2) assessing the probability and severity of risk, and 3) identifying ways in which the hazards can be controlled. The HACCP Team should ensure that the team complies with the terms of reference. There should be identification of the hazards, operational malpractices and contamination points (such as improper cleaning). Once the hazards have been identified, the control measures based on knowledge of the hazards, their normal sources and contamination points would then be constructed.

3.7 Determination of Microbiological Hazards
The decision tree approach was used for the team to look at the products, with the intention of identifying the microbiological hazards at HSL. Decision trees were structured in sets of questions. Typical questions include:
- Are control measures in place?
- Is control at this step necessary for safety?
- Does the step eliminate or reduce hazard occurrence to an acceptable level?
- Will contaminations occur at unacceptable levels or increase to unacceptable levels?
- Will a subsequent step eliminate or reduce hazard to acceptable levels?

In order to establish the hazardous organisms that may be associated with a particular food product, this process usually starts with a list of human food pathogens, followed by an evaluation of raw materials, production process and the possibility of contamination. Named pathogens presenting a possible risk are evaluated in relation to epidemiology data and their ability to cause illness, associated with a specific or related product.

Immediate potential hazards include the remaining pathogens with low minimum infective dose or not requiring growing in the food. Those microorganisms with a higher minimum infective dose or requiring growth receive further consideration. Estimates need to be made of the likelihood of these organisms growing in the food for consumer use. The role of the consumer and reasonable expected consumer abuse (RECA), product consumption and intended storage are also to be considered. This would lead to the identification of some microorganisms that are deemed marginal, meaning that the risk is present but at a low level. Once the potential pathogens are listed, it becomes possible to identify their main sources and possible contamination routes, which in turn assists in establishing the control measures.

3.8 Determination of Physical and Chemical Hazards
Physical and chemical hazards are both important in food safety and amount to numerous complaints about product quality. Customer complaint records are the most useful source of information on physical and chemical hazards. Examples of chemical hazards include cleaning chemicals, pesticides, toxic metals organic compounds and packaging plastizers. Contamination with chemical hazards can take place from farm to consumption. The minimum dose needed for some chemicals to cause acute illness is known but others have a chronic long-term effect following consumption of low levels over extended periods. Physical hazards can be classified into 5 major categories, namely glass, metal, wood, plastic and miscellaneous. Miscellaneous items include such as sand, paint stones, rubber and objectionable foreign matter that may not constitute a hazard.

It is important to consider how hazards can be present in the food product. Hazard analysis includes the identification of operational malpractices or events that lead to cross-contamination. The HACCP team verified the possible causes, identifying the
most important and prioritized action.

3.9 Conduct of Risk Assessment
Risk assessment is the process of evaluating food premises to decide if they need to be inspected frequently or not. Within HACCP, the risk concept is used to prioritize actions and determine level of control, and risk is defined as the likelihood or probability that a hazard will occur with consideration of severity. Risk can be quantified mathematically but this approach requires careful interpretation. Often the amount of raw data is inadequate or insufficient. An alternative is to consider food risk categories in high, medium or low degree (see Figure 3).

3.10 Identification of Critical Control Points and Target Levels
Once the hazards and how they get into food (i.e. sources and contamination points) are identified, control measures can be decided. A control measure is the action or activity required to eliminate a hazard or reduce its impact or occurrence to an acceptable level. More than one control measure may be required to control one hazard and more than one hazard may be controlled by one particular control measure. The work on risk assessment in combination with the damage potential (i.e. hazard severity) can assist to decide upon the level of control to be implemented. The control measures are also included in the Product Hazard Analysis.

In order to identify the control points, there are controllable steps in production within which: if an error happens the quality of the final product can be negatively influenced. Control measures are implemented at each critical point that is identified in the decision tree. A brief description of the action is included at this stage.

Results from control measures should be obtained rapidly and in time for remedial action to be taken. Statistical Process Control (SPC) is based on controlling the process to ensure the product consistently conforms to agreed specification. The SPC charts can monitor the performance of agreed HACCP critical limits. For each stage of the process for manufacturing Tortillaz Chips at HCL, quality audit sheets were used including the critical control limits and the cut off limits for the process parameter.

3.11 Monitoring of Safety Measures
Monitoring is the series of observations or measurements to ensure that controlled measures are being implemented correctly and within critical limits. Monitoring enables management to detect loss of control at a CCP. Hence, it is important to specify who, how and when monitoring is to be performed and recorded. Results from monitoring should be used proactively and illustrate how SPC can be incorporated into HACCP.

Monitoring can be continuous where important data is constantly being recorded, for example temperature graphs can be discontinuous with observations made and recorded at specific time intervals. Several types of monitoring activities are identified. These are:
Physical checks are manual and take the form of a simple test or following a standard operating procedure, and then a calculation followed by comparison to the set specifications for the process parameter. The measurement of percentage flavour of a product is a typical example. This requires weighing the flavoured and unflavoured chips and then a simple calculation.

Observation/Visual checks are best performed after training and testing for reliability and reproducibility against very specific criteria, which may include photographs, chart and timings. Visual inspection of surface cleanliness is the first part of an integrated approach to monitoring.

Microbiological checks require an outsourced laboratory or the establishment of an internal laboratory for testing under controlled environment.

Chemical checks usually involve a laboratory test. This is a technical procedure usually requiring the Quality Department staff to conduct this test.

3.12 Planning for Corrective/Improvement Actions

A Quality Plan shows the areas in which tests are carried out, with reference to the test procedure, who does the testing, the frequency, and the disposition of the product when out of specification. A Corrective/Improvement Action Plan describes what should happen if a deviation is found, meaning if the value of a measurement lies outside the critical limit. If this were to happen, there must have been a loss of process control (e.g. failure to achieve a specified pasteurization temperature or failure to clan properly). These plans are also used to specify what should happen if the results obtained at a critical control point are within a critical limit or not. Besides, documentation of the incident and the defective product is recorded on a Non-Conformance Report. This document is only completed when an investigation has been done, the defective product has been tested and a decision has been made on the release and outcome of the product.

Types of corrective/improvement actions that can be specified depend upon the hazard, the product and degree of deviation. This includes activities designed to ensure that the product is back under control and that control of the process is regained. If the investigation findings from the non-conformance report are such that the reasons for the non-conformance are ‘major’ leading to a breakdown in systems, a Corrective/Improvement Action (CIA) Request is issued. This document states the nature of the problem, the reason for the occurrence and the root cause and the actions to be taken to avoid another occurrence. This CIA request is issued to the departmental manager and has to be answered by a certain number of days and action to be implemented. Thereafter the area is audited for action being completed and verification of effectiveness of actions, meaning that there has not been a re-occurrence of the problem.

3.13 Verification of the HACCP Process and Documentation

Auditing is an important way of verifying HACCP plans. This is a systematic and independent examination to determine whether 1) HACCP activities and related results comply with planned arrangements, and 2) those arrangements are implemented effectively and are suitable to achieve objectives. There are basically three types of HACCP Audits - namely Internal (e.g. In-house auditors), External (e.g. Supplier or Contracted body) and Regulatory (e.g. Chemistry, Food and Drug inspectorate).

The management should coordinate the safety audits, maintain the safety records consistently, and reinforce the safety practices for HACCP audits. Organisations should document systems and add in the requirements for activities affecting food safety, quality and customer satisfaction. In this context, HSL has integrated its HACCP documentation into existing quality policies, procedures work instructions and record or reference a separate HACCP manual of its ISO 9001:2000 under Section 4.2: Quality Systems.

3.14 Reinforce Continuous Performance Improvements with HACCP

The management and the HACCP team should review the HACCP system at defined intervals sufficient to ensure its continuing suitability and effectiveness in satisfying the safety requirements and the company’s stated safety policy and objectives. Moreover, maintaining the safety culture with committed management and efficient management reviews would ensure that organisations stay ahead with continuous performance improvements (Pun and Hui, 2002).

4. Methods and Analysis of Findings

Customer Complaints and Non-Conformances were
two yardsticks by which the implementation of HACCP system was measured at HSL. It was through analysis of this information that the need for this implementation came about. A review on Customer Complaints lodged in the year prior to HACCP, and the year in which the work was done, was compared in order to investigate their impact on the system.

4.1 Customer Complaints
Customer complaints are major non-conformances and as such occur when issues are not detected and resolved in the manufacturing plant. Customer complaints are currently being measured as a key performance indicator (KPI) for the Company. Hence, this information is readily available and is analyzed and compiled as a monthly report. Table 1 shows the customer complaints for fiscal years 2004-2007 (data available up to April for 2007).

The three leading areas of concern were 1) foreign matter, 2) sensory or organoleptic issues, and 3) underweight and empty packs. Foreign matter was divided into metal and non-metal categories. For the metal category, this basically included such items as metal wields pieces of equipment. Screws, nuts and bolts etc originate from plant equipment, with the odd exception not being identified from the plant. The foreign matter category included items such as pieces of plexi-glass, paper napkins, wood, and other odd miscellaneous items. Besides, foreign matter was inclusive of products manufactured in the plant found in a pack of another product. This was a result of cross contamination due to a poor cleaning and sanitization of conveyors.

The sensory or organoleptic category included complaints such as soft or stale product, hard product or other texture issues, too salty and other characteristics with respect to the taste of the product. The under weight and empties category referred where a consumer obtained a pack of product which was not completely full or empty and was not detected by the manual packers on the packaging line. This was a result of negligence or human error. Moreover, the category of ‘Other’ included issues, which might have come from sales such as bad driving, incorrect sale of product or mistake with pricing. This category also included the complaints from outsourced products, in possibly the same areas identified for this manufacturing plant. These complaints were not under the control of this Company but the responsibility was accepted and conveyed to the country of manufacture.

<table>
<thead>
<tr>
<th>Criteria for customer complaints</th>
<th>F'05 Sept '04 – Aug '05</th>
<th>F'06 Sept '05 – Aug '06</th>
<th>F'07 Sept '06 – April '07</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of complaint</td>
<td>% of total</td>
<td># of complaint</td>
</tr>
<tr>
<td>Foreign Matter</td>
<td>118 30.2</td>
<td>137 34.1</td>
<td>60 25.9</td>
</tr>
<tr>
<td>Sensory / Organoleptic</td>
<td>97 24.8</td>
<td>92 22.9</td>
<td>38 16.3</td>
</tr>
<tr>
<td>Under weights / empties</td>
<td>96 24.6</td>
<td>110 27.4</td>
<td>73 31.5</td>
</tr>
<tr>
<td>Other</td>
<td>80 20.5</td>
<td>63 13.7</td>
<td>61 26.3</td>
</tr>
<tr>
<td>Total # of complaints</td>
<td>391</td>
<td>402</td>
<td>232</td>
</tr>
<tr>
<td>Tortillaz Chips complaints</td>
<td>125 32.0</td>
<td>172 42.7</td>
<td>44 21.1</td>
</tr>
</tbody>
</table>

4.2 Non-Conformances
Non-Conformances are defined as any incidents or occurrences, which are not within the documented specifications. These are divided into two categories, namely 1) major non-conformances and 2) minor non-conformances. Information collected is analyzed and compiled into a monthly report, as for customer complaints. Table 2 depicts a summary of non-conformances for fiscal years 2005, 2006 and 2007 (data available up to April for 2007).
Table 2: Summary of Non-Conformances for 2004-2007

<table>
<thead>
<tr>
<th>Criteria for Non Conformances (N.C.)</th>
<th>F’05 Sept ’04 – Aug ’05</th>
<th>F’06 Sept ’05 – Aug ’06</th>
<th>F’07 Sept ’06 – April ’07</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of N.C.</td>
<td>% of total</td>
<td># of N.C.</td>
</tr>
<tr>
<td>Personnel</td>
<td>280</td>
<td>45.1</td>
<td>309</td>
</tr>
<tr>
<td>Equipment / utilities malfunction</td>
<td>205</td>
<td>33.2</td>
<td>201</td>
</tr>
<tr>
<td>Contamination / Infestation</td>
<td>85</td>
<td>13.7</td>
<td>92</td>
</tr>
<tr>
<td>Other</td>
<td>51</td>
<td>8.2</td>
<td>71</td>
</tr>
<tr>
<td><strong>Total # of N.C.</strong></td>
<td><strong>621</strong></td>
<td></td>
<td><strong>673</strong></td>
</tr>
<tr>
<td>Tortillaz Chips N.C.</td>
<td>289</td>
<td>46.5</td>
<td>329</td>
</tr>
</tbody>
</table>

The top three areas of concern for the past years were 1) personnel, 2) equipment or utilities malfunction, and 3) contamination or infestation. The area of personnel can be defined as persons not following the normal standard operating procedure, lack of process control or negligence. This basically deals with the human aspect of the operation, for which there always existed a problem, but needs constant attention in the way of training reminders via notices, posters.

The next area of concern was equipment and utilities malfunction. This referred to any incident that caused loss of time in the manufacturing process (or Non-Productive time), as well as defective product. This could be the root cause for the aesthetic or texture issues with the product. Besides, contamination might mean one product mixed with another product during the process or a situation where due to inadequate cleaning particles from a previously manufactured product was brought into the current manufacture of a product.

The issue of infestation could occur in two areas: the raw material storage, where raw materials could be plagued by mould with incorrect storage conditions. Besides, insects such as weevils could manifest in products such as corn meal, corn masa or potato pellets. The next area of infestation is in the manufacturing plant itself, where there was always the possibility of pest infiltration into the process, whether they were flying or crawling insects.

The category of ‘Other’ included such issues as poor handling causing damage to the raw material or packaged product. Supplier issues was another area of concern, meaning defective product delivered to the plant, which needed special instructions for use rather than the standard parameters for processing or the product could not be used at all. In the latter case, this also implied the loss of storage space to the defective product, as well as the incurred demurrage costs. These areas of Non-Conformances were directly related to the Customer Complaints.

The major non-conformance classified as personnel was directly related to the areas of concern in Customer Complaints. Foreign matter inclusion such as paper napkins, hair and other miscellaneous items could be attributed to negligence in cleaning procedures or poor manufacturing practices such as not covering hair properly. For issues such as product mix-up, which was also in the area of foreign matter contamination that this can be as a result of equipment malfunction causing an overflow. As a customer Complaint, this was a very critical issue as it could cause further implications with consumers and allergens. For occurrences such as wood, this again could be caused by improper use of wooden pallets in the plant.

For foreign matter metal inclusion, the improper preparation of equipment for start up or insufficient maintenance checks could cause a metal bolt or nut for instance to be included in a pack. The category of sensory or organoleptic was also directly related to personnel, where procedures were not followed with respect to the product specifications. It could also imply no detection of an issue with raw materials before its use in the manufacturing process, this was attributed to negligence.

The complaint area of under weights and empties was another area that could be as a consequence of equipment malfunction with respect to the packaging machines as well as this was a personnel issue, whereby the defective packs should be detected by the packers on the packaging line as
4.3 Highlights of Accomplishments
The implementation of the HACCP system has been proven to assist in the prevention of food contamination at HSL. Customer Complaint have been reduced from 402 in Fiscal year 2006 to 232 in Fiscal Year 2007 (up to April), a 42.3% reduction. For Non-Conformances, there has been a reduction of 51.7% from 673 in Fiscal year 2006 to 325 in Fiscal Year 2007. Besides, this was evident by the reduction of Total Non-Conformances by 54.6%.

This was seen by the 71% reduction of issues in the area of Non-Conformances. The area of personnel issues have been reduced by 66.6%, equipment and utilities malfunction reduced by 75.6% and contamination or infestation reduced by 71.7% from Fiscal year 2006 to 2007. This can be attributed to a greater focus on following the standard operating procedures, and holding people accountable for their actions, so that there were fewer instances of negligence.

There was also stability and trust in the Company by the consumers as well as strength and confidence brought to the Brands. The main area of improvement was in the area of sensory/organoleptic, where there has been a 58.7% decrease. The foreign matter criteria were also drastically decreased (i.e. 56.2%). The issue of under weights and empty packs was reduced by 33.6%. This can be attributed to the increased focus put on training for the packers and extra checks or audits on the finished goods area.

5. Discussion
While food hygiene is concerned with a wide range of activities within a food and beverage operation and is ultimately the responsibility of the management, one cannot overlook the role that each employee plays in the implementation of the food hygiene system. By integrating food hygiene into the operational systems (manufacturing and checklists), a powerful message will be sent to the personnel that food hygiene is a primary function of the establishment and must at all times be enforced. The development of the HACCP system to a snack industry is based on this principle of importance of food hygiene.

The purpose of this trial implementation of the HACCP system on product line is to establish whether this approach is feasible for the implementation of the system to other production lines. This can be determined by the analysis of the measureables (such as, Customer Complaints and Non-Conformances). This can also be assessed by identifying the setbacks during the implementation process and the areas of improvement identified by the various steps or procedures taken. The HACCP system was incorporated into the existing ISO 9001:2000 Quality Management System (QMS) in the company. Training, enforcement, verification, product safety checks and audits of the HACCP system were conducted under the area of the QMS.

The steps of implementation and principles of HACCP were addressed separately and with details of the processing operation. These steps enforced proper investigations, root-cause analysis and documentation. The Product description was more detailed with emphasis on physical, chemical and microbiological aspects of the product. The process steps description and the flow diagram also showed clear guidelines of the product manufacture.

With respect to the Hazard Analysis of the product, CCPs were identified and the respective actions were described in the product hazard analysis. Severity and risk assessment of each critical area in the process was also evaluated. The major areas of concern, identified from the Customer Complaint data are foreign matters (i.e., metal versus non-metal), sensory or organoleptic and under weight or empty packs. These are directly related to the major issues in non-conformances in the plant, personnel, equipment or utilities malfunction and contamination and infestation. The data shows a gradual decreasing trend for both customer complaints and non-conformances with the implementation of the HACCP system.

While food hygiene is concerned with a wide range of activities within a food and beverage operation and is ultimately the responsibility of management, one cannot overlook the role that each employee plays in the implementation of the food hygiene system. By integrating food hygiene into the operational system, a powerful message is sent to the personnel that food hygiene is a primary function of the establishment. These areas identified will bring a greater value to the currently implemented system to the Tortillaz Chip product line as well as all the other product lines intended for HACCP implementation.

6. Conclusion
Many practitioners and researchers advocate that
achieving safety performance can help organisations foster their competitive edge (see, for example, Arnjadi and Hussain, 2005; Khatri and Collins, 2007; Pun and Hui, 2002). This is attributable to the minimization of financial loss, compliance with legislation, effective allocation of safety responsibilities, and promotion of community goodwill (Pun and Bhairo-Beekhoo, 2008).

This paper described the implementation of a 14-step strategy of HACCP system implementation for snack food manufacturing at HSL, where the work was limited to one product. Based on the results of the gap analysis, improvement was required in several areas, the most urgent being sanitation. Hence, a cause-and-effect diagram of poor sanitation was identified and this also contributed to the reduction of non-conformances in the plant.

Over the studied period, the HACCP implementation has made a tremendous contribution to improved personal hygiene of staff, manufacturing practices and sanitation and cleaning schemes. These are the key areas which have impacted on the reduction of Non-Conformances and Customer Complaints. HACCP concentrates prevention strategies on known hazards and the risks of the occurring at specific points in the food chain. Evidence shows that the trial implementation of the HACCP system for one product could be applicable to other product lines.

HSL has implemented HACCP for its own benefits and for obtaining the HACCP certification. Acquiring HACCP certification is not a condition of sale in Trinidad and Tobago. However, achievements from the implementation will promote the product, the quality and safety standards of the company in the eyes of the consumers. This also strengthens the brands of the company as well as promotes trust in the production of safe food to the consumers.

In order to attain safety performance for competitive edge, snack food manufacturers should expand hazard assessments to quantify consumer risks and potential hazard reduction. The HACCP system should be continuously revised to reflect ongoing changes to operating systems, work force, plant facilities and environment, as these would impact on the end product to the consumers.

The 14-step strategy model serves as a practical reference for snack food manufacturers to establish, implement and maintain their HACCP system. The model provides a process-oriented approach for helping organisations to go through the HACCP implementation in line with the safety management requirements and HACCP principles. This also assists them in maintaining the HACCP system and reinforces continuous improvement in safety performance.

Future research using comparative studies is suggested to investigate the determinants of the HACCP system implementation and a holistic paradigm that aligns HACCP measures for attaining safety performance goals in the snack industry sectors. Moreover, future work could be enhanced through improvements in the acquisition of timely and properly processes data, and the methodologies used to elicit empirical information.

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A Novel Control Strategy for an Ammonia Marine Loading Arm

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Abstract This paper presents the design and development of a personal computer based, novel strategy to automate the processes of monitoring and controlling of a manually operated Ammonia Marine Loading Arm. State of art, industry standard monitoring and control equipment is used and an operator friendly, real-time visual interface is developed to display overall operating process. This approach reduces the overall operating cost and improves safety standards during product loading.

Keywords: Control strategy, loading arm, industry standard, monitoring and control equipment

1. Introduction
Marine loading arms are commonly used to fueling purposes and transfer liquids into ocean freight tankers, trucks, railcars, and other vehicles. YARA Trinidad Limited has been in the ammonia manufacturing business for over 40 years and exports about 1.2 million metric tons annually. The company presently owns and operates three ammonia plants and two shore/ship loading facilities with a manually operated marine loading arm facility to load ocean freight tankers with anhydrous ammonia. Ammonia is a colorless gas with a very sharp odour and also known as ammonia gas or anhydrous (i.e. without water) ammonia. Ammonia has wide spread usage and applications in several industries. Anhydrous ammonia is transported via ocean freight tankers to several client facilities in North and South America, Europe and Asia. Marine loading arms are used to load ocean freight tankers with anhydrous ammonia.

Marine loading arms are available in different configurations (GlobalSpec, 2008) for different purposes; such as counterweighted loaders, vapour recovery loaders, top loaders, bottom loaders, pantographs or scissor arms, slide sleeves, wash arms etc. Most of the loading arms are made of aluminium, carbon steel, low-temperature carbon steel, or aluminium.

A general marine loading arm comprises of a base raiser, inboard and outboard arms along with other several components. Components and accessories for loading arms include dry break couplers, mechanical or pneumatic breakaway couplers, shut-off valves, level sensors, vacuum breakers, and deflectors. The articulation is assured by swivel arrangements. Swivel joints allow the rotation between two items of a product line whilst ensuring no product leakage, when under pressure or vacuum. These arrangements allow for complete movement in all planes. Once the loading arm is connected to the flange of the ship, the arm is free to follow the normal movement of a properly moored ship at berth.

2. Existing Problems with Manually Operated Loading Arm
At present, YARA Trinidad is using a manually operated, Rotary Counterweighted Marine Arm (RCMA) for product loading operations. An ocean freight tanker will be connected to the pier during the loading operations. The actual loading arm in the standard hold position and during operation is shown
in Figure 1.

Unexpected movements caused by the ocean wave buoyancy will result in the drifting of the ship away from the shoreline, thereby pulling the connected loading arm with it. This can cause significant damage to the loading arm facility that may result in the release of liquid ammonia to the atmosphere. Ammonia is caustic and can cause serious health damage to the people and the environment. If the movements of the loading arm exceed the maximum possible extension limits, the loading process needs to be shutdown to avoid the release of ammonia into the atmosphere.

![Figure 1: Rotary Counterweighted Marine Loading Arm at the YARA, Trinidad site](image)

Safety of the operators during product loading is another major concern. Though, manufacturers of marine loading arms provide the safe operating zones, field operators are responsible for monitoring the operations. In the absence of automatic monitoring and control mechanisms the results can be devastating in case of any mishap.

Several incidents in the past resulted in damages to the loading arm and forced the company to pay the maintenance costs and demurrage costs to the tanker for additional time spent at the loading facility. These costs are substantial and directly affect the profits. On the other hand, the existing shutdown infrastructure is a hardwired-relay base system involving electromechanical relays, timers, and push-buttons. Several spurious trips have been experienced that resulted in the initiation of shutdown procedures, causing the stoppage of the product loading.

Hence, product loading operations require constant monitoring to detect motion of the loading arm and to initiate the shutdown procedures if required. Presently no proximity detection system exists to safely detect and determine whether the marine loading arm is moving beyond its safe operating limits. Integrating a state-of-art proximity detection system within the existing, phased-out shutdown protection systems is not practical due to incompatibilities between the new and old technologies.

Though design and construction specifications for marine loading arms are available (OCIMF, 2001), generic solutions to automate the manually operated marine loading arms have not been reported in the literature so far. Manufacturers encourage their clients to purchase hydraulically balanced loading arms at much higher cost. Organizations in Trinidad are reluctant to procure hydraulically balanced loading arms as both the maintenance costs and the downtimes are higher due to its complex, proprietary technologies.

A few companies (FMC, 2008) which manufacture the loading arms supply proprietary control mechanisms along with their loading arms, as an optional feature. However, such solutions are product specific and hence cannot be applied to other types of loading arms, especially to the manually operated types. Also these optional control technology features are prohibitively expensive and will come with usage licenses over fixed time periods. Keeping in view the above, a new real-time control strategy was developed to automate
monitoring, controlling of the loading arm.

3. Overall Design for Monitoring and Control
The major objective of the control strategy is to ensure effective unmanned product loading thus maintaining occupational safety standards. Two levels of alarms (i.e. warning level and danger level) are designed. The shutdown procedures will be initiated automatically if the danger level alarm is activated. The control mechanism is then tested and implemented using the state of a Programmable Logic Controller (PLC) and a user-friendly Human Machine Interface (HMI). The complete control system with its major components is shown below in Figure 2.

![Figure 2: The schematic of the developed system to monitor and control the loading arm](image_url)

4. Deployment of Position Sensors and Control Logic
Position sensors are widely adopted in industries for real-time monitoring and control applications due to the inherent advantages such as the accurate position sensing, ability to communicate with other digital equipment etc (Scheible et al, 2007). The monitoring of the loading arm is achieved by the position sensors which will be able to determine whether the arm has reached its maximum extended limits. State of art inductive proximity sensors are used for this purpose.

The inductive proximity sensors have several advantages over other types of sensors such as sensitivity to metallic objects, fail-safe switching, and abilities to operate under polluted, dusty open environments etc (Toolingu, 2008). These sensors are installed at specific, pre-designated locations on the loading arm based on maximum allowable extension limits and to capture movements in all
three planes i.e. in/out, left/right and up/down, since the loading arm can move in three different planes.

Steel sheets attached to the swivel joints are used as the target material for the inductive proximity sensors, so that when the arm moves out of specific limits in any of the three planes, the proximity sensors will sense and trigger a change in output state. For normal operating zones, the target materials will uncover the proximity sensors and for abnormal operating zone, the target materials will cover the proximity sensors. The arrangement of target materials and the proximity sensors is shown in Figure 3.

![Figure 3: Arrangement of target material and the proximity sensors](image)

The control design incorporates two stages of protection for movements in each plane. The first stage will be a warning or alert alarm and the second stage will be a danger or shutdown alarm. When the arm is moving outwards and enters a predetermined distance, first stage sensors will activate the first stage control by triggering an audible alarm. However, if the arm continues to move further outwards and enters a predetermined zone, second stage sensors will activate the second stage control which triggers the standard shutdown procedures. This sequence of events will be the same for the left/right and up/down movements. The loading arm movement boundaries and the areas of operation are shown in Figure 4.

The first stage control will be activating a field mounted audible horn with flashing strobe (i.e. steady audible tone with a yellow flashing strobe light at a particular frequency) and a control room audible horn with flashing indication, which will be displayed on the HMI system through the PLC. The Siemens STEP 7-Micro/Win 32 software is used as the configuration tool for the S7-200 PLC, to model the movements of the loading arm, develop the ladder logic configuration and to download the final version on the PCL. Figure 6 shows the process of modeling the arm movements and the control strategies using STEP 7-Micro/Win 32 software.
5. Development of Operator Interface

At present, there is no visual indication for the operators and hence, the manual operations require a team to monitor the product handling process. The team members are located in different places; near the loading arm, near the shutdown control panel and flow-trip valve, etc. STEP7-Micro/WIN32 environment cannot be used for designing an HMI for process control. Hence, an operator-friendly graphical interface was developed using the industry standard Citect HMI development system to monitor and control the loading arm movements in the real-time.

The Citect HMI system is a powerful windows-based suite of software system that can be used to design any process monitoring and control applications, and can be easily integrated to PLC systems. Figure 7 shows the developed operator interface from which the operator can monitor total operation. This is to reduce the training time of operators and also make the real-time operation very simple.

Citect (2008) has two distinct operating modes - Configuration and Runtime which support the testing of the developed interfaces in both simulation and real-time modes. Hence, the Siemens PLC is the prime controller of this process in determining the sequence of events. This is driven by the Citect HMI, though it can be manually operated if necessary. Thus, Citect-based HMI provides the much required visual indication of the whole operation to the operator and also provides means of controlling.

6. Advantages of the Developed Control Strategy

There are no changes in the operational and shutdown procedures. The developed system completely works over the existing infrastructure and automates manually operated procedures thereby improving occupational safety standards. Routine testing of the process shutdown trips will now be provided by the software-based logic design as opposed to the existing complex, hardwired logic design.

The developed system can handle up to four marine loading arms at the same time, where at present only one loading arm can be used at any given instant. The present operating procedures require a fire tender to be stationed at a total cost of TTD 4000 per hour. This costs TTD 192,000 for 48 hours operation.
The developed system does not require an onsite fire tender, as the valves will be tripped and the process will be shutdown automatically in case of abnormal movements of loading arm. This automatically eliminates the release of ammonia into the atmosphere. The other advantages are – Elimination of manual monitoring, less likelihood of individual component failure, reduction in repair cost and resources, mitigation of nuisance trips, improved diagnostic capabilities and faster routine testing of system.

7. Conclusion
A real-time monitoring and control strategy has been successfully designed and developed to automate the existing manually operated RCMA type marine loading arm facility at the YARA Trinidad site. This approach improves the level of safety during the loading of anhydrous ammonia from shore to ship and also eliminates the need of a manned fire tender on site while loading ammonia. The combination of technologies gives the operators greater flexibility to monitor the product handling process at much lesser operating costs. Due to the generic design features, this control philosophy can be used with any type of marine loading arm.
8. References


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Biographical Notes:

Nigel Ugas received his Technician Diploma with special options in Power Systems and Microprocessor Technology from S. Donaldson Technical Institute, Trinidad in 1991. He has been working with YARA Trinidad Ltd since 1991 and his current designation is Senior Electrical Engineer.
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