FACTORS CONTRIBUTING TO BOM CHANGE MANAGEMENT ISSUES- *THE CASE OF TIS DEPARTMENT IN LEADOFF ENGINEERING TECHNOLOGIES (M) INCORPORATED*

ANISHA BANU DAWOOD GANI

ROSDIANA BINTI MOHD ROSLI

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DECLARATION

We, Anisha Banu Bt Dawood Gani, (PGSM0002/12) and Rosdiana Bt Rosli (PSGM0286/11) hereby declare that the contents presented in this research are our own work which was done at Universiti Sains Malaysia unless stated otherwise. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions. The research was done under the guidance of Deputy Dean of Graduate School of Business, Tuan Haji Noor Nasir Bin Kader Ali. The research has not been previously submitted for any other degree.

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Yours Sincerely,

(Anisha Banu)	and	(Rosdiana Rosli)
+60164858537		+60194789918

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In the Name of Allah, the Beneficent, the Merciful

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Abstrak

Pengurusan yang cekap terhadap sebarang perubahan dalam bahan pembinaan (BOM) adalah kritikal dalam industri pembuatan kerana ada kemungkinan perubahan yang diusulkan merebak dari satu komponen ke komponen yang lain. Pasukan Perkhidmatan Maklumat Teknikal (TIS) di Leadoff Engineering Technologies (LET) telah diberi kepercayaan untuk memberitahu dan mendapatkan kelulusan daripada semua pihak berkepentingan apabila perubahan kejuruteraan dimulakan terhadap BOM. Walau bagaimanapun, aduan baru-baru ini daripada Pelanggan Dalaman (IC) yang gagal untuk menerima laporan tersebut dari TIS, mendedahkan jurang di dalam cara TIS menguruskan proses ini. Tujuan kajian ini adalah untuk mendedahkan penyebab kepada variasi di dalam proses dan mengenal pasti punca yang menyumbang kepada jurang pengetahuan di kalangan TIS, demi mencadangkan penyelesaian yang praktikal untuk menanganinya. Dalam usaha mencapai matlamat ini, siri analisis awal menggunakan tinjauan dan temu bual yang telah dilakukan mendedahkan amalan yang berbeza di kalangan TIS dalam menguruskan perubahan kejuruteraan. Untuk mengkaji punca-punca yang menyebabkan jurang ini, analisis yang mendalam telah dijalankan dengan menggunakan alat 'gejala -lawan- masalah' (SVP). SVP ialah teknik menggunakan gambar rajah untuk mengenal pasti punca gejala yang berlaku. Ia menggambarkan hubungan antara gejala dan semua faktor-faktor yang mempengaruhi kejadian itu secara grafik.

Analisis SVP mendedahkan empat masalah yang menyumbang kepada ketiadaan notis perubahan iaitu: i) prosedur operasi standard (SOP) yang generik dan tidak jelas, ii) tiada SOP dan pasukan yang berdedikasi untuk mengendalikan latihan kerja (OJT), iii) kurang kesedaran di kalangan TIS mengenai kesan akibat tindakan mereka dan akhir sekali, iv) tiada kekerapan audit bagi memastikan pematuhan TIS terhadap

SOP. Setiap masalah yang dikenal pasti telah diberikan penyelesaian masing-masing iaitu: i) mengemaskini SOP untuk kejelasan, ii) membangunkan SOP untuk latihan, iii) mengukuhkan latihan kesedaran terhadap kesan perubahan BOM dan iv) menjalankan audit secara berkala untuk memastikan pematuhan TIS terhadap SOP. Semua penyelesaian ini akan membolehkan aliran maklumat yang tepat kepada semua pihak-pihak berkepentingan dalaman dan luaran , mengurangkan kos produk, meningkatkan kepuasan pelanggan dan memberi kesan positif terhadap reputasi dan keuntungan syarikat.

Abstract

Effectively managing a bills-of-material (BOM) change is critical in a manufacturing industry because of the possibility of a change to spread from one component to another. The Technical Information Service team (TIS) at Leadoff Engineering Technologies (LET) is entrusted to notify and obtain approval from all impacted stakeholders when an engineering change is initiated against a BOM. However, a recent complaint from an Internal Customer (IC) who failed to receive such notification from TIS, revealed a process gap in the way TIS manages this process. The purpose of this study is to uncover reasons for the process variations and identify the causes contributing to the knowledge gaps among TIS, in order to propose practical solutions to address it. In pursuit of these goals, series of preliminary analysis using surveys and interviews were carried out which exposed differing practices among TIS in managing an engineering change. To unearth the root causes for these gaps, an in-depth analysis was carried out using 'symptom-versus-problem' (SVP) tool. SVP is a diagram based technique that is used to identify the root cause of a symptom that is occurring. It graphically illustrates the relationship between a symptom and all the factors that influences its occurrences.

SVP analysis reveals four major problems that were contributing to the absence of change notice: i) generic and unclear standard operating procedures (SOP), ii) no SOP and dedicated team for on-the-job (OJT) training, iii) lack of awareness among the TIS on the repercussion of their actions and lastly, iv) lack of compliance audit to ensure TIS's adherence to SOP's. Each of the problems identified were given a corresponding solution to: i) update SOP's for clarity, ii) develop SOP for training, iii) reinforce awareness training on BOM change

repercussions and iv) conduct periodic audits to ensure TIS's compliance to SOP. All these solutions would enable an accurate flow of information to both internal and external stakeholders, reduce product cost, increase customer satisfaction and positively impact the company's reputation and revenue.

Key words: Engineering Change, Engineering Change Management, Engineering Change Process, Bills-of-Materials, BOM

EXECUTIVE SUMMARY

This case study was undertaken to examine why the communication gap between Technical Information Service team (TIS) and internal customers has occurred--in relation to managing a bills-of-material (BOM) change-- and to recommend ways to prevent its recurrence.

The research draws attention to the fact that Leadoff Engineering Technologies (LET) was the pioneer and leader in the electronic measurement industry until it was dethroned in 2013-- with only four hundred million dollars (USD $400M) in differences-- by its closest competitor. One of the possible causes that lead to their poor financial performance is ineffective BOM change management process. TIS are responsible to ensure all users were notified, aligned and in agreement prior implementing a change against a part, processes or standards. However, TIS received a complaint that a BOM change was not communicated to the internal stakeholders which had resulted in wastages in term of rework and resource cost. One of the possible repercussions of BOM inaccuracies is incorrect shipments to customers, which would cost six thousand dollars (USD $6K) each to rectify.

The initial finding revealed differing practices among TIS in managing an engineering change. Further investigation exposed four major problems that were contributing to the absence of a change notice:

i)SOP (un)availability and (in)accuracies - There are some missing SOP for training and process controls which opens up avenue for TIS to create their own version as applicable to the divisions they support, resulting in unauthorized and uncontrolled processes.

ii. (Lack of) Training- There is no SOP for training resulting in variations in training method and knowledge transfer quality.

iii. Compliance – TIS are not being audited for process compliance at regular intervals.

iv. (Lack) of Awareness- Some TIS are working in silos without being aware of their contributions and the repercussion of an error to the company's dependent ecosystem (integrated systems.

Each of the problems identified were given a corresponding solution in order to prevent the issue recurrence. Taking into consideration the time and resource factor needed to implement the proposed recommendations, the TIS management is given an immediate, short term and long term action plan to spread out the activities. All the solutions proposed would enable an accurate flow of information to both internal and external stakeholders, reduce product cost, increase customer satisfaction and positively impact the company's reputation and revenue.

The limitation of this research is that it is only focused on one opportunity area in TIS in regards to its corporate governance. However, there are other factors beyond TIS that could contribute to BOM inaccuracies, but not explored in this study. LET would benefit from expanding this research to other areas e.g. materials and engineering department, to identify other opportunities to strengthen the quality of its BOM and information flow to all stakeholders.

CHAPTER 1

This chapter provides a background on the importance of Engineering Change in a manufacturing industry. Next, a short description of the case study company, Leadoff Engineering Technologies[1] (LET) is provided. Thereafter, the problem statement and the research questions are presented. The chapter ends by outlining the scope and limitations of this research.

1. INTRODUCTION

Engineering changes[2] (EC) are inevitable in a manufacturing industry. The need to modify, improvise and enhance an assembly or product's Bills-of-Material (BOM) increasingly becomes synonym with product offerings that adds-value to and in-line with quality-thirst customer expectations. Effective EC management enables a company to match the technological innovations of rivals and can help to develop a competitive advantage (DiPrima, 1982). An EC process can be triggered at any point in the product life-cycle once the concept has been selected and any changes to this information as the product evolves is regarded as an EC process (Jarrat et.al. 2006).

A well-managed EC is essential for businesses to compete in the future (Terwiesch & Loch, 1999). Due to the complex nature of the industry with variety of interrelated operations, an EC 'might propagate (spread) within and across multiple boundaries' (Hamraz et al., 2012). Therefore, 'effectively managing an EC is a critical task in engineering change management (ECM)

[1]The original company name has been changed to Leadoff Engineering Technologies (LET), an imaginary, non-existent company at the time of publication, to preserve the anonymity.

[2]The term 'engineering change' in this research context refers to Bills of Materials changes and is used interchangeably.

process. It ensures that the latest version of modifications, product and process data items and specifications are in the right place at the right time (Chen et al.,2002).

However, the ability of a company to implement changes effectively and efficiently is largely dependent upon the people carrying out the task, the way they communicate and disseminate that information to all stakeholders. Failure to cascade information on the changes made to relevant parties and in a timely manner, could prove costly to the organization.

1.1 Case Background

LET acquired a company from Malaga, Spain (Malaga) in 2012 to strengthen its wireless communications solution offerings (LET, 2012). As a result of the acquisition, all of the operational data from Malaga were required to be integrated into LET's enterprise resource planning (ERP) system, Oracle. LET has established a company-wide effort to migrate from all of its legacy ERP systems to a single infrastructure system since June, 2002. The intent is to gain control of its global supply chain and subsequently drive benefits to customers, suppliers and the company as a result of integrated supply chain capabilities.

In reviewing the Malaga's manufacturing data to be migrated into Oracle, the project team had identified two distinct categories; a) unique parts and b) common parts. Unique parts are parts that are unique to Malaga which requires a brand new setup in Oracle, whereas a common part refers to parts that are similar in nature, if not identical, which already exists in Oracle and are being shared among all business divisions in LET.

The decision was made to include Malaga among the division to co-share the common parts. The significance of this decision therein lies with a timely notice to all shared users on any proposed changes to the common parts. Failure to keep all impacted users informed or worse, executing a change to a shared part without informing all users could result in a situation undesired for business continuity. As LET later discovers, the worst has happened.

Malaga's team was not communicated on a change made to a firmware, which is being used in their system, resulting in the R&D engineers having to rework and modify the instrument drivers to make it compatible. Malaga's New Product Introduction (NPI) Manager escalated the issue to on-site manufacturing representatives in LET Penang requesting a thorough investigation of the root cause and corrective action to avoid the same in future:

*"*R&D needs to be informed, in advance, when there is a plan to change the firmware of an instrument that is in use in some of our products, for example the Product A or Product B or Product C[3], etc. In some cases we have found that after the change in the software our tests cases don't do work and we need to do some changes on the instruments drivers."- NPI Manager, Leadoff Engineering Technologies, Malaga (*Appendix 1)*

1.2 Problem Statement

LET has over ten (10) different product lines supporting a range of over 60 types of products (LET, Product & Services) that co-share identical components in their BOM. Therefore, any changes to the shared components require all product lines, i.e. stakeholders, approval prior implementation lest it has an

[3] Product names have been disguised without impacting the message context

impact on their BOM. TIS are the team responsible to ensure all users were notified and in agreement prior implementing a change against a part. However, initial investigation revealed different practices within TIS in managing a change notice communication (*Appendix 2*). These variations amongst TIS are resulting in some stakeholder's right to review and assess an EC's impact being mistakenly ignored. Implementing a BOM change without thorough analysis by all stakeholders poses threat to the company in prematurely releasing an incompatible product to both internal and external customers, in addition to possible safety and quality concern. This communication fallout also rebuts TIS's credibility as a data quality enforcement agent. Hence, it is necessary to study the reasons contributing to the process variations amongst TIS which results in ineffective BOM change management.

1.3 Research Objectives

The objectives of this study are:

i. To uncover the reasons for the process variations practiced by TIS
ii. To identify the causes of the knowledge gap among TIS that's causing the variation
iii. To recommend practical solutions for the organization to address the gap in (1) & (2)

1.4 Research Question

In order to achieve the research objectives, the following research questions (RQ) need to be analyzed and answered:

RQ1: Why is there process variation among TIS?

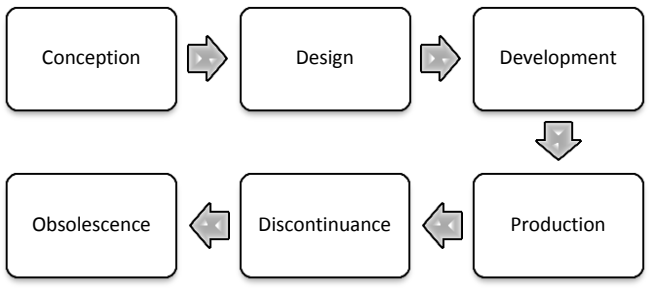
RQ2: What is causing the knowledge gap among TIS?

RQ3: How can TIS department improve the knowledge gap and process variations found in RQ1 and RQ2?

1.5 Definitions of terms and concepts

This table summarizes the commonly used terms and concepts in this research paper. The terms are defined according to how they are used in this research, and might have different definitions in other contexts and organizations.

Concept	Explanation
i. Bills-of-Material (BOM)	A BOM is a detailed list of all parts and subassemblies that are required to build a specific product, including the quantity necessary for each unit to be produced. In LET, this is also known as 'Parent-Child' or Parent/Sub-Parent relationships. Parent: The 1st or top hierarchical order of the BOM Child/Sub Parent – The 2nd or bottom hierarchical order of the BOM Figure 8 illustrates the Parent-Child relationship of a BOM
ii. Engineering change	"An engineering change is an alteration made to parts, drawings or software that have already been released during the product design process. The change can be of any size or type; the change can involve any number of people and take any length of time" (Jarratt, Eckert, & Caldwell, 2010, p. 106). In the context of this study, an Engineering Change is also interchangeably used as a

		BOM change notice.
iii.	Engineering Change Management (ECM)	Engineering change management (ECM) refers to the organization, control and execution of ECs (Jarrat et al, 2011) and covers the product life cycle from the selection of a concept to the wind-down of production and support. The goals of ECM are to avoid or reduce the number of engineering change requests (ECRs) before they occur, to select their implementation effectively when they occur, to implement required ECs efficiently, and to learn from implemented ECs (Hamraz et al.,2012)
iv.	Internal Customer (IC) / Stakeholders/ Change board	A cross-functional team used in order to facilitate communication and ensure that all aspects of the change will be considered. The change board usually has the authority to prioritize, reject and approve change requests/orders.
v.	Product Life-Cycle (PLC)	Describes the cycle of a product from Conception, Design, Development, Production, Discontinuance and finally Obsolescence (out of support).  Diagram: General PLC Flow
vi.	TIS Coordinator	A person responsible for coordination of change requests

(TIS)	and change orders in the Product Life-cycle Management (PLM) system.

1.6 Purpose of Study

Based on a survey performed by Huang and Mak (1999) poor communication is one of the major factors influencing the management of engineering changes. Also Tavacar and Duhovnik (2005) mentioned poor communication as being the most common reason for problems. However, in the context of EC, the factors that could influence the effectiveness of the communication is not particularly explored. Therefore, this case study of LET is undertaken to identify factors that could impact the communication process in EC. Next the possible methods to be adopted in overcoming them shall be explored. The goal is to contribute new knowledge to LET in particular to the area of engineering changes by concentrating specifically on the TIS function. However, the finding and learning outcome may be further examined in future research to a wider participant.

1.7 Significance of the Study

The outcome of this research is intended to help LET avoid losses either in a form of financial or non-financial as a result of ineffective EC management processes. In identifying the root causes for the BOM change notices not communicated up-to parent users, TIS management can take proactive action to avoid such recurrence in future, thereby effectively improving the data quality of the BOM structures in LET. Moreover, TIS's reputation as the team entrusted to enforce compliance requirements and standards for data management in Oracle can be restored

1.8 Scope and Limitations

This research was conducted at LET with a focus on its TIS department's ECM process, and in particular in the BOM change context. As this is a case study research, it might suffer bias in data interpretation and presenting facts because of author's subjectivity.

While the study is unique to TIS functions, the lessons learnt can be leveraged to other functions within LET and to other companies outside of LET with adjustments necessary. The academia and literature shared can be applied to any companies EC management practices for improvement considerations. The proposed recommendation is given based on researcher's analysis on the problem which is unique to TIS function in LET. The TIS Management has full discretion, to adopt the proposal provided or deploy completely different approach as they deem fit for their organization.

1.9 Research Outline

This paper will be divided into nine chapters and an appendix section. The first chapter will provide a brief introduction about the case background in the selected organization, the problem statement, objectives and rationale for the study. The second chapter will describe the research methods used, including the rationale for using qualitative research methods, data collection strategies and analysis tool selected. Chapter three will present a comprehensive review of the literature. Chapter four will present the industry and company analysis as well as the relationship with the case study. Chapter five will present the detailed case issues and preliminary findings. Chapter six will present and highlight an in-depth step-by-step analysis of the issues identified in previous chapter using the analysis tool and discuss the results of the study. Chapter seven will present

researchers' proposal to the organization in addressing problems identified. Chapter eight will conclude the case and findings; and the last chapter will present a section on lessons learned and future research. Subsequent sections will present a list of the references used in all the chapters of this paper. There will also be appendix sections that include copies of data collection evidence and preliminary survey findings.

CHAPTER 2

In this chapter the research strategy is presented and rationale for the chosen strategy is explained. This is followed by an overview of the research process and an explanation of the data collection process. This chapter ends with justification of the tools used for data analysis.

2. METHODOLOGY

2.1 Research Strategy

A qualitative research strategy has been applied to this research because the purpose is to create a deeper insight into the reasons why the BOM change notice was not communicated to stakeholders i.e. all product line users. This research strategy has an emphasis on understanding and interpreting information from individuals' or a small group's perspective (Ghauri & Gronhaug, 2005).

As the purpose of this study is to improve the BOM Change notification process, it is important to understand the process from the TIS's points of view, share their experiences and interpret their problems in a wider perspective. The aim of a qualitative study is not to test theories, but rather to create theories (Bryman & Bell, 2003). In this study, this concerned identifying the causes behind process variations and knowledge gap among TIS and how the process could be improved at LET. The qualitative strategy and the case study design were brought together; and the typical data collection method, i.e. interviews, which is recommended by Bryman and Bell (2003), were applied in this research.

2.2 Data Collection

All the data sources with the exception of literature reviews were of primary in nature, collected either via an electronic survey (polling), face-to-face interviews

and internal business process document (also known as ISO Document) review (Appendix 3). Sequences of the data gathering were:

i. Electronic polls/survey was used to identify the approaches TIS use in identifying common-part user; i.e. Internal Customer (IC) for EC notifications. (Appendix 2)
ii. Interview with all 22 respondents to understand the reason for differing practices in response to (i). (Appendix 4)
iii. Informal interview and ISO process document review session with Product Configuration Specialist in TIS Department

2.3 Data Linkages.

Research Questions	Data Source	Justifications
RQ1: Why is there process variation among TIS personnel?	1. Survey (polling) to TIS personnel's involved in EC communication process 2. Interview with Poll respondents 3. Interview with Product Configuration Specialist	1. To understand the causes for varying TIS practices 2. Analyzing the completeness of current (ISO) business process documents used
RQ2: What is	1. Interview with Poll	To identify the factors

causing the knowledge gap among TIS personnel?	respondents 2. Interview with Product Configuration Specialist 3. ISO/Business process document review 4. SVP Analysis	contributing to the knowledge gap and to segregate the *Symptoms* from the *Problems*
RQ3: How can TIS department improve the knowledge gap and process variations found in RQ1 and RQ2?	Researchers proposed recommendation based on problems identified	To provide practical solutions to overcome EC/BOM change notice management issue