EMPLOYEE PERCEPTION ON LEAN PRACTICES IN THE INTERNAL SUPPLY CHAIN PERFORMANCE

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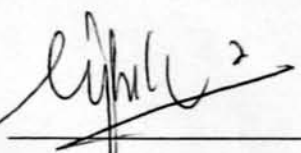
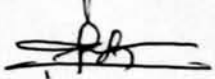
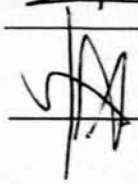
Pengerusi Viva *(Chairman for Viva)*	: **Assoc. Prof. Dr. Shahizan bin Hassan**	Tandatangan *(Signature)*	
Pemeriksa Luar *(External Examiner)*	: **Assoc. Prof. Dr. Zafir Khan bin Mohamed Makhbul**	Tandatangan *(Signature)*	
Pemeriksa Dalam *(Internal Examiner)*	: **Dr. Norlena binti Hasnan**	Tandatangan *(Signature)*	

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ABSTRACT

In today's highly competitive world where most businesses focus on cost and quality, organizations with efficient and effective supply chains are able to stand out with inherent competitive advantages. To achieve this many organizations adopt lean practices which fundamentally stress on the elimination of non-value added tasks (such as unwanted transportation, extra processing, excess motion, repairs on defects, over production, excess inventory and incidents of waiting or delays). Nevertheless, the introduction of lean practices in any organization is often accompanied by changes in the working environment. These changes influence the people working there. This dissertation looks into the perceptions of the workers, in a case study site (a Japanese Multi-National Corporation situated in Penang, Malaysia producing semi-conductor devices), on the lean practices implemented in the internal supply chains. The study compared the perceptions using a self-administered questionnaire. Perceptions of those highly exposed to lean practices were compared against the perceptions of those with low exposure. A Significant difference, in the perceptions of those who had high exposures to lean practices as compared to those with low exposures pertaining to the internal supply chain performances, was found. The perceptions obtained proved useful as empirical studies showed negative implications such as the deteriorations in employee emotions, attitudes, behaviors, commitments and turnovers. Moreover, the perceptions of the employees and the employers also did not match. Observations and interviews carried out are displayed in the paper to support and explain the findings. The body of knowledge from the empirical data collected in this study and its interpretation should prove useful for both academics exploring similar fields or leverages and practitioners keen on implementing lean practices or planning to learn from others. Actual cases of how lean practices affect the internal supply chains are quoted. These cases complement the many academic articles discussed throughout the dissertation. Useful recommendations have been put forth which could be used for improving the internal supply chain performances of other organizations. The recommendations encompass areas such as resource allocations, mind-set changes, trainings, personnel and lean practice implementation strategies.

Keywords: Lean Practices, Internal Supply Chain Performance, Lean Manufacturing

ABSTRAK

Dalam dunia kompetitif hari ini, kebanyakan perniagaan memberikan tumpuan kepada kos dan kualiti. Di samping itu, organisasi dapat menonjolkan daya saing yang tinggi apabila mempunyai rantaian bekalan yang cekap dan berkesan. Untuk mencapai matlamat ini, kebanyakan organisasi mengamalkan amalan berhemat. Secara dasarnya matlamat ini boleh dicapai apabila organisasi menumpukan kepada beberapa tindakan penghapusan yang tidak bernilai seperti pengangkutan yang tidak perlu, pemprosesan tambahan, gerakan yang berlebihan, kerja membaiki-pulih kerosakan, pengeluaran yang berlebihan, inventori yang terlalu tinggi dan kelewatan. Walau bagaimanapun, pelaksanaan amalan berhemat dalam setiap organisasi biasanya disertai oleh perubahan dalam persekitaran kerja. Perubahan ini akan mempengaruhi pekerja-pekerja di kawasan tersebut. Disertasi ini mengkaji persepsi individu yang bekerja di sebuah tapak kajian kes iaitu sebuah kilang Jepun Perbadanan Multi-Nasional yang mengeluarkan peranti semi-konduktor di Pulau Pinang, Malaysia. Tesis ini mengkaji amalan berhemat yang dilaksanakan dalam rantaian bekalan dalaman. Kajian ini melibatkan perbandingan persepsi yang diukur dengan menggunakan borang soal selidik. Soal selidik meneliti persepsi mereka yang mempunyai pendedahan yang luas kepada amalan berhemat jika dibandingkan dengan persepsi mereka yang mempunyai pendedahan yang kurang. Hasil kajian mendapati bahawa terdapat perbezaan yang signifikan dalam persepsi mereka yang mempunyai pendedahan yang luas kepada amalan berhemat berbanding dengan mereka yang mempunyai pendedahan yang kurang berkaitan dengan prestasi rantaian bekalan dalaman. Hal ini adalah penting untuk mendapatkan persepsi kerana kajian empirikal telah menunjukkan implikasi negatif seperti kemerosotan emosi pekerja, sikap, tingkah laku, komitmen dan perolehan apabila persepsi di antara pekerja dan majikan tidak sepadan. Pemerhatian dan temu bual telah dijalankan dan dinyatakan dalam kajian ini untuk menyokong dan menjelaskan penemuan-penemuannya. Kajian ini menambah kepada pengetahuan berdasarkan data empirikal yang dikumpul dan tafsirannya. Oleh itu, kajian ini berguna untuk pihak ahli akademik (yang ingin meneroka ke dalam bidang yang sama atau memanfaatkan penemuan ini) dan pengamal (yang berminat untuk melaksanakan amalan berhemat dan ingin belajar daripada yang lain). Dalam disertasi ini kes-kes sebenar seperti cara pelaksanaan amalan berhemat yang memberi kesan kepada rantaian bekalan dalaman dikemukakan. Ini selaras dengan pandangan dalam banyak artikel akademik yang telah pun dibincangkan dalam kajian ini. Beberapa cadangan berguna telah dikemukakan bagi meningkatkan prestasi rantaian bekalan dalaman di organisasi yang lain. Saranan-saranan ini merangkumi bidang-bidang seperti peruntukan sumber, perubahan pemikiran, latihan, kakitangan dan strategi pelaksanaan amalan berhemat.

Kata kunci: Amalan Berhemat, Prestasi Rantaian Bekalan Dalaman, Pembuatan Berhemat

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CEO	Chief Executive Officer
CFM	Cut Mark Form
df	Degree of Freedom
EMP	Electronic Marketplaces
EOL	End of Line
ERP	Enterprise Resources Planning
FIFO	First in First out
FVI	Final Visual Inspection
FOL	Front of Line
ICT	Information and Communication Technology
iPS	Innovative Production System
ISO 9000	International System Organization 9000
IT	Information Technology
JIT	Just in Time
KIT	Kaizen Innovative Team
KPI	Key Performance Indicator
LCD	Liquid Crystal Display
LSPS	Low Stage Power Supply
MD	Managing Director
MES	Manufacturing Execution System
MIDA	Malaysian Industrial Development Authority
MOL	Middle of Line
MNC	Multi National Corporation
MTBC	Mean Time Between Chokotei ("Chokotei"-Japanese word for Reset)
NVA	Non-value adding
NNVA	Necessary but non-value adding
n	Sample Size
OEE	Overall Equipment Efficiency
OTRS	Operation Time Research Software
p	Probability
PJ	Project

PwTRS	Power Transistor
QCC	Quality Control Circle
RENESAS	Renaissance Semiconductor for Advanced Solutions
RFID	Radio Frequency Identification
ROE	Return on Equity
ROI	Return on Investment
RSM	Renesas Semiconductor Malaysia
SCC	Supply Chain Council
SCM	Supply Chain Management
SCT	Supply Chain Technology
SCOR	Supply-Chain Operations References
SGA	Small Group Activities
SME	Small and medium enterprises
SMED	Single Minute Exchange of Die
SPSS	Statistical Packages for the Social Sciences
ST	Standard Time
TAT	Turn around Time
TPM	Total Preventive Maintenance
TPS	Toyota Production System
UOM	Unit of Measurement
UK	United Kingdom
USA	United States of America
VA	Value Added
VSM	Value Stream Mapping
WIP	Work in Process
ZD	Zero Defects

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CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

In today's level of unprecedented global competition, companies must stay competitive through improved manufacturing operations. To do so, the organizations need use its resources (such as human, machines etc) efficiently and effectively, which in literature is commonly known as lean manufacturing. Apart from this the organization need to not only use existing resources more efficiently, but creatively (Ahmed, 2009). Lean manufacturing (applying lean practices) has been used to improve the operational performance through eliminating waste or "muda" (in Japanese) where waste is anything other than the minimum amount of equipment, material, parts and working time, which are absolutely vital to production. The focal point of lean manufacturing is cost reduction through the elimination of waste, thereby improving profitability (Lynch, 2005). Despite wide knowledge and resources, many companies are struggling to become or stay lean (Taj & Morosan, 2011). As such companies need to evaluate or assess their current state of operations to see if the mutual beliefs, perceptions and informal obligations between the stakeholders are aligned or otherwise (Kickul, Scott & Belgio, 2004). Being aligned will give the organization a significant source of competitive advantage (Clutterbuck, 2005) in contrast to the negative effect of not being aligned. In fact empirical studies have shown the downward adjustments in various employee emotions, attitudes and behaviours, including organizational commitment (Lester, Turnley, Bloodgood & Bolino, 2002), increased turnover (Maertz & Griffeth, 2004), and increased deviant behaviors (Kickul, 2001) when there is misalignment.

Starting from the 90's, many companies tried to transform their conventional manufacturing line into lean manufacturing by either transforming their entire processes or by creating new cellular production systems (Liker, 1997; Womack & Jones, 1996). Lean manufacturing is much more than a technique, rather it is a new way of thinking and a holistic system approach that create a culture in which everyone in the organization continuously improves the operations (Liker & Franz, 2011; Liker, 2004). This way of thinking has its origin in the work that was originally undertaken to understand the phenomenal success of Japanese industry then, primarily in the automotive sector and specifically in Toyota (Womack, Jones & Roos, 1990). The Toyota approach is famously known as Toyota Production System (TPS) with an interesting history. Kiichiro Toyoda, the founder of Toyota Automotive Industries and Taiichi Ohno who was a member of his staff (Shingo, 1989), was credited with the creation of TPS which became lean manufacturing (Holweg, 2007). This lean manufacturing approach is very much the dominant paradigm in many writings related to the area of supply chain performance (Cox, 1999).

With the acceleration of global competition mentioned, supply chain performance has become a critical source of sustainable advantage in many industries. In fact research has shown that companies with more mature supply chain practices are reducing costs faster than their less mature peers and achieving higher profit margins (Hoole, 2005). Industry leaders are using this advantage to increase their market share and to drive out competition.

Among the issues faced by the industries at large are problems linked to poor communication, new product launches, over-reliance on technology etc (Barratt, 2004). To overcome, the strategy adopted by many were to implement lean manufacturing or to

adopt TPS where the aim is to reduce inventory, optimize space utilization, implement effective layout etc, in order to improve productivity and maximize profit (Khanna & Shankar, 2008). One particular area of focus that has been looked into for many years is in the manufacturing process where the organizations would strive to improve the efficiency of their internal supply chain (Ellinger, 2002; Fawcett & Magnan, 2002). The area of improving the internal supply chain has become even more critical with the rise of low cost manufacturers in countries like China where market share has increased just from the standpoint of price competitiveness alone.

1.1.1 Internal Supply Chain

It is said that the way companies compete these days have changed much. Gone are the days where emphasis on customer loyalty is supreme (though it still is important). There has been a shift to producing high quality products at reasonable cost, but this trend has also lost its lure in gaining competitive advantage. Today the emphasis has been much on delivering products to customers at the right time, at the right place and at the right price (Chin, Tummala, Rao, Leung & Tang, 2004). Other writers elaborate this further by describing the primary role of firms is to meet customer requirement in terms of providing them with the right product (Dale, Lascelles & Lloyd, 1994), of the right quality (Brewer & Speh, 2000; Carmignani, 2009), right quantity (Chan, Humphreys & Lu, 2001), right source (Carr & Smeltzer, 1999) at the right price (Chin *et al.*, 2004) and finally using the right technology (Boubekri, 2001; Basnet, Corner, Wisner & Tan, 2003).

In fact, nowadays competition among companies is becoming more intense and no longer between companies and companies, but supply chains to supply chains

(Christopher, 1992; Li, Nathan, Nathan & Rao, 2004). Studies towards achieving improved supply chain have gained the attention of both the academics and practitioners especially in today's challenging environment (Bechtel & Jayaram, 1977; Burgess, Singh & Koroglu, 2006). Coordination and integration of these flows and their respective activities internally and externally are critical for effective Supply Chain Management (SCM) which is a vital element for operational success (Croom, Romano & Giannakis, 2000). Having an appropriate strategy to attain efficient supply chain performance, should be the goal of an organization in order to excel (Childhouse & Towill, 2003).

While the environment becomes more competitive (and more internationalized), demands from customers such as having more product mix, better quality, better service and faster delivery are becoming common (Quah, 2010). Many firms are realizing that effective supply chain is the key to building and sustaining competitive advantage for what they produce (whether in tangible goods or in intangible services). There are concerted effort to find ways to improve performance of their supply chains through studies such as those that focus on the flexibility and capability of the supply chain (Li, 2002; Quah & Udin, 2011).

The supply chain basically covers the external supply chain (such as the supply chain across businesses, for example between suppliers and the manufacturer or the customers and the manufacturer) as well as the lesser emphasized internal supply chain (such as the supply chain within a particular company, for example from one process to another or from one department to another, in the organization). This is in-line with a definition on supply chain management which was phrased as below:

"Supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole" (Mentzer, 2001).

Issues with supply chain involve the material and information flow and apply for the external and the internal supply chain. Utilizing strategies organizations aim to improve their supply chain so that products are produced in the right quantities, in the right location or process and at the right time. In this way the cost of making the goods could be minimized. Researchers believe that supply chains are a supplemental factor, if not a main driver, to increased profitability, competitive advantage and customer satisfaction (Chase & Jacobs, 2007; Mentzer, 2001).

It was stated that the design of information flow in the supply chain (both internally and externally) has traditionally followed the physical (material) flow (Kaipia, 2009). As such in many cases the poor performance of the supply chain can be traced to poor information sharing or flow. Indeed for an organization to succeed it was found that excellent information flow is a necessity (Eshbach, 2004). The information flow may take the form of writing, using the broadcast media, use of e-mail and other communication technologies in this digital age (Yeomans, 2007).

Adopting advanced information systems, which enable a more efficient information sharing, may however change the situation. In-fact instead of facing shortage of data or information, the challenge faced by companies which chose to adopt this would be how it could achieve good quality information so that ultimately it could be used to improve

the performance of the internal supply chain (Wagner, 2002). Improving the information flow contributes not only to the organizational efficiency but it also brings about the non tangible aspects such as job satisfaction. An example can be seen from a research done in Australia, which shows that employees or staff satisfaction is very much correlated (0.7) to effective communication (Gray & Robertson, 2005). In order to improve the information flow approaches to counter it comes in the form such as "efficient channels of communication", "teamwork", "close collaboration with suppliers", "customer orientation" etc. (Warnecke & Huser, 1995).

The wide spread use of modern information and communication technologies, among organizations today is because they realize that this tool helps to improve their supply chain performance which ultimately leads to effective communication (Lee, Chu & Tseng, 2011). Effective communication results in building and maintaining rapport which brings about positive impacts such as improved motivation level etc (Linke & Zerfass, 2011). In the internal aspect, reasons for the increased importance of communication are such as workplace change, increased complexity in the world of work, need for transfer of knowledge, emphasis of being a learning organization etc. In order to achieve these (and bearing in mind the often widespread distribution of staffs geographically), there is a need to engage communication technologies and networks. As a matter of fact the use of information communication technology (ICT) is considered a prerequisite for the effective control of today's complex supply chains. It has redefined how businesses work together, raised customer expectations, and placed new demands on supply chain performance. This is especially so with recent proven technologies that has fast return-on-investment (ROI) such as the use of radio frequency identification (RFID) technology in enhancing the supply chain (Attaran, 2007).

Complex and comprehensive infrastructures support the firm's communications network, databases, and operating systems. This works towards the improving the performance of their supply chains by managing and integrating key information elements via the power of technology (Byrd & Davidson, 2003; Brandyberry, Rai & White, 1999; Gunasekaran & Ngai, 2003; Handfield & Nichols, 1999; Vickery, Jayaram, Droge & Calantone, 2003). Technology should be used to influence company growth, provide competitive edge, and enable implementation of business strategies as well as to sustain it (Ward, 1987). This view was also echoed by Benjamin, Rockart, Scott & Wyman (1984) in which they developed a framework which suggested companies can effectively utilize ICT to gain competitive advantage. Similarly a research in Malaysia pertaining to factors affecting the supply chain (in a case study site producing electronics component) found that ICT was among the few critical success factors identified (Thoo, Huam, Md & Rasli, 2010).

Despite the wide acceptance of technology in improving the supply chain some organizations resort to the use of traditional ways such as manually updating information on boards or any physical displays rather than some automatic electronic gadgets where information are shown on a real time basis (Liker & Franz, 2011; Liker, 2004). Basic reasoning in being skeptical of this medium lies with the way information is made available with minimal interaction from the user. By using the traditional way of even manually updating data the advantage would be that the personnel involved would be able to digest the information more accurately and this essentially improves the quality of information flow though it may not provide the speed of information flow. This line of thought agrees with many studies which highlight the short-comings of ICT in improving communication (Boon-itt & Wong, 2010; Cagliano, Caniato & Gianluca, 2006; Vickery, Drogea, Setiab & Sambamurthya, 2010; Li, Yang, Sun & Sohal, 2008;

Tan, Kannan, Hsu & Leong, 2010; Jeffers, Muhanna & Nault, 2008; Ward & Zhou, 2006; Zhang, Donk & Vaart, 2011).

1.1.2 Lean Practices

In lean the essence of the strategy is basically to have a company-wide integrated effort to achieve process improvement and waste reduction (Upadhye, Deshmukh & Garg, 2010). Lean practices refers to the practices common to the organizations implementing lean manufacturing. An understanding of how actual lean practices influence plant performance and which practices have the greatest impact on particular areas of plant performance may assist managers to better allocate resources in response to competitive priorities (Watson, 2010). Furthermore literatures have highlighted the need to understand practices that affect the supply chain management as it is becoming an essential prerequisite, to remaining in the competitive global race and to grow profitably (Moberg, Cutler, Gross & Speh, 2002; Power, Sohal & Rahman, 2001; Sezen, 2008). It has to be noted that though some organizations have realized the importance of implementing practices such as lean practices to improve the supply chain management, they often do not know exactly what to implement, due to a lack of understanding of what constitute a comprehensive set of practices (Li Lin, Wang & Yan, 2006). For example, in the case of the semiconductor industry in Malaysia, Rajagopal, Zailani and Sulaiman (2009), discussed on the reasons why firms in general were reluctant to emphasize supply chain partnering in order to improve their supply chain despite knowing its importance for performance (such as cost inventory reduction through lean practices). The firms gave reasons such as the lack of human resource, issues of confidentiality (which hinders flow of information) and financial constraint in developing a supply chain infrastructure to establish communication between them.

Even though the findings would be limited in its generalization due to it being only a comparison between two companies it does shed some light as to the scenario in the world at large and in Malaysia in particular. This is reinforced by others who felt that in the midst of numerous failures in implementing practices to improve the supply chain the question remains whether any practices (such as lean practices) could positively impact the supply chain performance (Handfield & Nichols, 1999; Tan, Kannan, Handfield & Ghosh, 1999).

Lean practices basically rides on the theory of constraints (Goldratt, 1990) that aims to initiate and implement breakthrough improvement through focusing on a constraint that prevents a system from achieving a higher level of performance. It states that every firm must have at least one constraint which is defined by Goldratt and Cox (1992) as any element or factor that limits the system from doing more of what it was designed to accomplish. By working on this identified constraint the performance (internal supply chain) of the organization would be improved. The theory encourages managers to identify what is preventing them from moving towards their goals and to find relevant solutions moving forward.

Lean practices implementation was found to be effective in improving the information flow (Puvanasvaran, Megat, Hong & Razali, 2009; Worley & Doolen, 2006) which in turn is key to increasing productivity, (Clampitt & Down, 1993) and ultimately the internal supply chain. Apart from this it also has a strong influence on the integration of both information and physical flow along the supply chain (Cagliano *et al.*, 2006). This would result in cost efficiency as waste are eliminated or reduced through lowering of inventory and focus on improving the quality of products in the supply chain (Huang, Uppal & Shi, 2002; Wang, Huang & Dismukes, 2004;

Vonderembse, Uppal, Huang & Dismukes, 2006). This thought is reinforced by Christopher and Towill (2000), who stressed the importance of lead time (Turn-around-Time) reduction in a lean implementation. They argue that in the implementation, the supply chain works well where demand is relatively stable and predictable with low variety of products type. This argument however is to a certain extent disqualified by Vitasek, Manrodt and Abbott (2005) when they highlighted some attributes that are relevant in a lean implementation. These are a) ability to better manage capability through obtaining the demand data efficiently such as through effective use of information communication technology (ICT). This concurs with the view by Galbraith (1973), who puts forth his opinion of the importance of effectively and efficiently processing the necessary information required. b) waste and cost reduction through policy, procedures and practices that eliminates waste, c) determining the best way to manage a process and then standardizing it across the chain, d) cultural change in getting the lean concepts accepted in the organization and e) ability to garner the members in the supply chain towards maximizing the value stream.

Though technology has made many fast communication channels available to the masses, the aim is not about only being fast but rather being effective and efficient. Towards this end, lean practices provides a great potential as was shown in a research (a printed circuit board electronics manufacturer located in United States of America) which highlighted improved information flow through the implementation (Worley & Doolen, 2006). Pertaining to this similar field, in a Malaysian context, a group of researchers did a study and made the same findings in an aerospace manufacturing company (Puvanasvaran *et al.*, 2009).

Lean practices by itself have come a long way (being made prominent particularly in the automobile industry). After the publication of Womack *et al.*, (1990) and the other seminal works describing TPS (Monden, 1983; Ohno, 1988; Shingo, 1989), many other notable articles associated with TPS were produced. There are indeed many success stories of how employing lean practice brings about positive results. This trend shows increase in the number of organizations and industries embracing lean practices (Manrodt, Thompson & Vitasek, 2009). It is spurred on by studies that shows lean practices not only display superior performance, but also that these practices were not culturally bound to one country and thus indeed transferable to other countries and organizations (Holweg, 2007). Examples of successful implementation of lean practices can be seen in countries such as in Japan (Imai, 1986), India (Upadhye *et al.*, 2010), China (Taj, 2008), United States (Engum, 2009), United Kingdom (Anthony, Kumar & Madu, 2005) as well as in Malaysia (Mohamad, Abdullah & Wan, 2008).

Prominent examples can be seen in Toyota (Liker, 2004; Womack & Jones, 2005) not only in Japan but elsewhere as stated earlier. Among the issues that are commonly faced by organizations which prompt them to consider implementing lean practices are such as decision making (Summers & Scherpereel, 2008), key performance indicators (Fullerton & Wempe, 2009), inventory control (Koumanakos, 2008), communicating to the shop floor the top management strategy (Yang & Su, 2007), managing of change (Smeds, 1994) and leadership (Herkness, 2005).

The root of lean practices (lean manufacturing) started from the automobile industries (Worley & Doolen, 2006) and its success lies in having a workforce that is committed (Adler, 1993; Angelis, Conti, Cooper & Gill, 2011; Schonberger, 2007; Wickens, 1987; Womack *et al.*, 1990). The practice became famous through the work of

Womack *et al.* (1990) in the book "The Machine that Changed the World" and since then the philosophy of lean has spread into diverse industries. To name a few it has being utilized in the printing industry (Engum, 2009), agriculture (Sofokleous, 2007), medical device (David, 2007), aerospace (Mathaisel, 2005), meat processing (Simons & Zokaei, 2005), textile, food and chemical (Koumanakos, 2008) etc. Lean practices has also penetrated into the electronic industries (Anthony *et al.*, 2005) of which some studies were carried out also in Malaysia (Wong *et al.*, 2009).

Though isolated studies on lean practices in Malaysia had been carried out by various individuals and groups such as the study on Lean practices implementation in the Malaysian electrical and electronics industry (Wong, Wong & Ali, 2009), the number of studies has been by far few.

1.2 **Problem Statement**

In today's competitive global market, many companies face an increasing level of wastes and high costs. The marketplace wants to pay less for the products. Cutting costs is just not enough to survive. In order for a company to stay competitive, develop and sustain jobs, and continue having new business across the enterprise, it must create new ways to make its products less costly and more competitive (Jenkins, 2002). Some organizations chose to adopt lean practices which mainly concentrate on the identification and elimination of waste in the supply chain, and by doing so discover that it help in reducing waste while improving quality (Liker & Franz, 2011; Liker, 2004; Mortimer, 2006; Simon & Zokaei, 2005; Taj, 2008). It focuses on enhancing the product to better meet the customer needs and expectations and in doing so provides the internal and external customers the needed product, at the needed time, and at the

desirable cost (Chin *et al.*, 2004). Indeed this view is shared by others who taught that with lean practices the main emphasis is on how waste can be eliminated or reduced so that the organization becomes more efficient and the supply chain improves (Chopra & Meindl, 2001).

Indeed meeting customer's demands in a satisfactory and economically viable way is the challenge faced by most organizations. With growing pressure from customers and competitors it is becoming difficult for managers to strike a balance between customer requirement and demand fulfillments. Though in general it cannot be denied that the strategy adopted by an organization is dependent upon their environment as stated in the contingency theory which says that there is no best way to run an organization but that the decision on what is most suitable is contingent upon the circumstances (Donaldson, 2001, Lawrence & Lorsch, 1967), many organizations have found that adopting the lean path have brought about many success stories (Anthony *et al.*, 2005; Engum, 2009; Imai, 1986; Mohamad, *et al.*, 2008; Taj, 2008; Upadhye *et al.*, 2010). This is despite the fact that though initially used in the automotive industry, lean principles are increasingly being applied to other sectors (Cudney & Elrod, 2011). With respect to the supply chain it has become a preferred strategy for many organizations (since they believe that effective SCM is the key to building and sustaining competitive advantage for their products or services) and this has prompted many to do research in these areas (Hassini, 2008; Spekman, Kamauff & Myhr, 1998). In the Malaysian context recent work by Meysam, Reza and Shahryar (2012) inform that many local companies are not as good as their international counterpart when it comes to lean practices implementation that influence the internal supply chain. In the work by Agus and Hajinoor (2012) on lean practices implementation for companies situated in

Malaysia, they concluded that companies should marshal their effort to implement a more effective lean SCM.

Even though there are many lean practices as can be seen in literature (Shah & Ward 2003) not all are implemented by any one organization. In general the success of implementation frequently depends upon organizational characteristics and not all organizations can or should implement the same set of practices (Galbraith, 1977). As a matter of comparison, in the work by Shah and Ward (2003), the number of practices discussed by differing sources range from 4 to 15 out of a list of 22 as shown in Table 1.1.

Table 1.1

Count of Lean Practices Discussed in Shah & Ward (2003)

	Count of lean practices discussed by sources															
Sources	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	■	■	■	■	■											
2	■	■	■	■	■	■	■	■								
3	■	■	■	■	■											
4	■	■	■	■												
5	■	■	■	■	■											
6	■	■	■	■	■	■	■	■								
7	■	■	■	■	■	■	■									
8	■	■	■	■	■	■	■	■								
9	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
10	■	■	■	■	■											
11	■	■	■	■	■	■	■	■	■	■	■					
12	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
13	■	■	■	■	■	■	■	■	■	■	■	■	■			
14	■	■	■	■	■	■	■	■	■	■	■					
15	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
16	■	■	■	■	■	■	■	■	■	■	■					

For any organization intending to implement lean practices it would be important to know what practices have a more significant effect on the supply chain rather than striving to implement as many practices as possible. By concentrating on the few

practices (since resources are limited) that matters most to the organization it can then better utilize its resources so as to maximize on its implementation. In the case studied by Singh *et al.* (2010), the researches shows the benefit of implementing practices such as 5S, visual management and layout change towards an improved supply chain. This and other studies (Zolait, Ibrahim, Chandran & Sundram, 2010, Thoo *et al.*, 2010, Leng & Zailani, 2012) lend to the need for more cases to be studied as each organization's environment is unique.

Recommendations for future research by Pinheiro (2010) in the area of lean implementation dwell on the need to pursue more work to obtain the viewpoints of people working in the site (not only top management or just a few key personnel). He stress the need for academic research on how people feel and what motivates (their perception) them in a lean implementation. This is because as organizations become more complex and global, the needs and views of the people driving the change will become as important as the bottom line.

1.3 **Research Objectives**

The objectives for this research are summarized as below.

1. To investigate the effect of Lean Practices on employees' perception of Internal Supply Chain performance.
    a. To investigate the effect of Cellular Layout on employees' perception of Internal Supply Chain Performance
    b. To investigate the effect of 5S on employees' perception of Internal Supply Chain Performance

c. To investigate the effect of Visual Management on employees' perception of Internal Supply Chain Performance

d. To investigate the effect of Teams on employees' perception of Internal Supply Chain Performance

e. To investigate the effect of Lean Organizational Structure on employees' perception of Internal Supply Chain Performance

2. To investigate the relationship between Lean Practices and Internal Supply Chain Performance.

3. To investigate the difference in perception of Internal Supply Chain Performance in terms of:

   a. gender

   b. job function

   c.. length of service

   d. section

   e. race

   f. educational level

As for the scope of this research the lean practices are the ones that are adopted in the case study site as described in the operational definition. These practices are also mentioned in various researches such as by Kundu, Manohar and Bairi (2011) as well as Olivella, Cuatrecasas and Gavilan (2008). The employees are exposed to the various lean practices, though not equally as it depends on what job function they work in. Some are exposed more highly then another and would be segregated based on their perception which will be obtained from the questionnaire.

1.4 Research Questions

The present study was designed to address specifically the research questions as below:

1. Does Lean Practices have a significant effect on employees' perceptions of Internal Supply Chain Performance?
    a. Does the implementation of Cellular Layout have a significant effect on employees' perception of Internal Supply Chain Performance?
    b. Does the practice of 5S have a significant effect on employees' perception of Internal Supply Chain Performance?
    c. Does the use of Visual Management have a significant effect on employees' perception of Internal Supply Chain Performance?
    d. Does Teams have a significant effect on employees' perception of Internal Supply Chain Performance?
    e. Does Lean Organizational Structure practiced have a significant effect on employees' perception of Internal Supply Chain Performance?

2. Is there a significant correlation between Lean Practices and Internal Supply Chain Performance?

3. Is there a significant difference in employees' perception of Internal Supply Chain Performance in terms of:
    a. gender
    b. job function
    c. length of service

d. section

e. race

f. educational level

1.5 Hypotheses

In making the hypotheses certain criteria would need to be taken into consideration. It should among other things stand a test (be empirically tested), be expressed in clear language, logical, simplistic and specific. By so call forcing a formal statement, hypothesis actually enable the researcher to be clear about what they expect to find through the study (Zikmund, 2003). Based on the relationship between the various variables, the hypotheses put forward in this research can be stated as below.

H_1 1 : There is a significant difference in employees' perceptions of Internal Supply Chain Performance between those with high exposure to Lean Practices and those with low exposure

H_1 1a : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to Cellular Layout

H_1 1b : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to 5S practiced

H_1 1_c: Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect Visual Management.

H_1 1_d : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to Teams

H_1 1_e : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to Lean Organizational Structure.

H_1 2 : There is a significant correlation between Lean Practices and Internal Supply Chain Performance

H_1 3a : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of gender

H_1 3b : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of job function

H_1 3c : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of length of service

H_1 3d : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of section

H_1 3e : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of race

H_1 3f : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of educational level

1.6 Operational Definition

Terms used in this study are defined as below.

Lean Practices

Though in literature there are many lean practices (Shah & Ward, 2003), for the purpose of this study, it is referred to the selected practices which consist of Cellular Layout, 5S, Visual Management, Teams and Lean Organizational Structure.

Cellular Layout

This refers to the layout concept whereby processes are brought together in a cell instead of the conventional layout where processes are isolated.

5S

5S refers to the housekeeping activity of keeping things in order, clean and well maintained. It follows a general guideline (Imai, 2001) as well as some specific guidelines set by the organization itself.

Visual Management

Visual Management as stated in this study refers to the intentional effort in making a situation or scenario clear to all interested parties. It encompass items such as making a clear display to showcase the production status or the use of Kanban cards in the production floor etc.

Teams

This refers to a group of workers either in the same job function or cross functional who comes together to solve a work related problem. It is formally recognized by the organization and are usually in groups of 6-10 persons.

Lean Organizational Structure

This refers to the flat organizational structure whereby hierarchy is reduced so as to improve on the communication of the work site.

Internal Supply Chain Performance

This refers to the ability of the organization to meet the customer's request (customer responsiveness). It encompasses areas such as meeting the customers' time line satisfactorily, providing a short order-to-delivery cycle time and responding to a customer request promptly.

Exposure to Lean Practices

In this study, respondents are categorized as having a high exposure to lean practices if the mean of their responds to the questionnaire on lean practices is above 3.01. Those that are below this value will be categorized as having a low exposure to lean practices.

1.7 Scope of Study

In the work by Sundram, Ibrahim and Govindaraju, (2011), they discussed the lacking and limited research (as apparent in the few published studies) on supply chain practices in the electronics industry in Malaysia. To date the limited research in the area of supply chain performance are mainly in countries such as New Zealand (Basnet *et al.*, 2003), Pakistan (Bhutta, Rana & Asad, 2007), Hong Kong (Chin *et al.*, 2004) , the United States of America (Gowen & Tallon, 2003; Hong & Jeong, 2006), the United Kingdom (Holt & Ghobadian, 2009) and Turkey (Koh, Demirbag, Bayraktar, Tatoglu & Zaim, 2007). Apart from the lacking studies in developing countries, the importance of doing this research in the Malaysian context is justified by the fact that the electrical and electronics industry contribute significantly to this country. According to MIDA (2010), gross output of the industry totaled RM166.2 billion (US$55.8 billion), while the industry's exports amounted to RM249.8 billion (US$83.8). This translates to a manufacturing output of 31%, exports of 48.7% and employment of 33.7% (336,408 people). Being such a prominent player in this sector, the study to be carried out would provide useful insight for both practitioners as well as academics.

The research is based specifically on Renesas Semiconductor (Malaysia) Sdn Bhd, which is located in Penang, Malaysia. It is a Japanese owned multinational company producing semiconductors for the export market. This is an empirical study on a prominent organization within the electrical and electronic manufacturing industry. Based on the "Final Worldwide Revenue Ranking for the Top-25 Semiconductor Suppliers" (IHS, 2011), this organization is ranked fifth in the world as its revenue account for 3.9% of the worldwide total. The positive as well as negative effect of the internal supply chain of an organization such as Renesas Semiconductor (Malaysia) Sdn

Bhd have much implication as it seeks to improve its bottom-line for a better competitive advantage.

Though in literature there are many lean practices mentioned such as the list by Shah and Ward (2003) where he identifies 22 practices, the scope of this study covers the common ones which are practiced in the case study site.

Cellular Layout – this is more than a layout; it is work connected in time, space and information (Olivella *et al.*, 2008). In a normal cellular layout, multiple processes are linked or cluttered together in one operation area. This is in contrast to conventional layout where the processes will be isolate from one another.

5S refers to the practice of good housekeeping. It has implication not only from the aspect of keeping things in good stead (clean and orderly etc), but that with it the operation would be able to run smoothly with minimal waste.

Visual Management refers to the aspect of making things obvious. This would entail physical indications (could be manual or electronic) of important items such as Key Performance Indicators (KPI), status of machines, work in progress (WIP) etc.

Teams refer to the formation of formal groups in the organization with aim of improving problems faced by the members themselves. It is at the heart of an organization claiming to practice lean (Womack *et al.*, 1990).

Lean Organizational Structure stresses the need to have fewer levels of management or a flatter organization (Olivella, *et al.*, 2008). A typical practice in lean

would be to have a personnel taking charge of more processes (vertical integration) instead of the conventional where she focus on a few processes (horizontal).

As for the internal supply chain performance it covers the aspect of supply chain flexibility, supply chain integration and customer responsiveness (Beamon, 1999).

1.8 Significance of the Study

Significance of the study is discussed in terms of its literature and practical contributions.

1.8.1 Literature Contribution

This study will be able to contribute to the body of knowledge in internal supply chain performance and lean manufacturing or practices. There are many articles in the field of supply chain management, as can be seen in the abundance of journals tabulated (3511 articles even way back in 2003) by research (Burgess *et al.*, 2006). However there are very few which covers the area of internal supply chain performance and lean manufacturing. A check on Emerald (as of 13th August 2011) shows that out of 11,761 articles on supply chain management, only a small percentage (3%) touch on the area of lean manufacturing.

1.8.2 Practical Contribution

This research would be able to provide useful insight for interested parties who are keen to study how they could improve their internal supply chain performance (for better competitiveness) through implementing lean practices. Though there are many practices in lean, the research will reveal some significant ones which would have a significant effect on the organization. For practitioners, they could tap on the findings to decide which practice to emphasize, since it is virtually impossible to try out all the practices by a single organization. It can be said that with this additional information, the best practices pertaining to improving the internal supply chain can be studied and adopted. This in a practical way would result in performance improvement and are among the benefits of best practices (Zairi & Al-Mashari, 2005).

By doing this research in a selected case scenario, many practical examples on how lean practices could affect the internal supply chain would be highlighted. In this way the readers could get a clearer grasp of the subjects. Pitfalls can be avoided as it is a wise thing to learn from others and in the final analysis, the organization would benefit through improved bottom-line.

1.9 Organization of the Dissertation

The structure of this dissertation is organized as with this chapter one providing the introduction, background and justification towards this particular research. It covers the question of why this research is being carried out, what are the issues and what it aims to achieve. In Chapter two it reviews previous literature on theories and empirical

findings. It also presents the literature review on the SCM definition, the theories and other variables being used in this study. Chapter three shows the research methodology such as research design, sampling etc. Chapter four would then focus on the data analysis techniques carried out for this study. Chapter five would present the results and findings from the analysis made, descriptive statistics etc. This last chapter will also summarize and discuss the findings in relation to the research objectives, contributions, limitations and recommendations for future research.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter attempts to provide literature reviews related to the following areas of study: Supply Chain (focusing on internal supply chain performance) and Lean Manufacturing (focusing on lean practices). The literature review will focus on concepts, principles, theories and previous research related to this study. All the variables in the research framework will be supported by the literatures reviewed in this chapter. The review in general will cover a broad scan (relies chiefly on review of the literature to help identify the research problem), a focused review (providing a knowledge base for the research) and a comprehensive critique (locating research that has direct bearing on the research problem) (Glatthorn, 1998).

2.2 Scenario of Supply Chain

There have been many attempts to describe and define what supply chain is all about. Chopra & Meindl, (2004) puts supply chain as consisting of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves. According to them in each organization, such as the manufacturer, the supply chain includes all functions involved in receiving and filling a customer request. These functions include, but are not limited to, new product development, marketing, operations, distribution, finance, and customer service. Another writer attempts to describe supply chain as a system of organizations, people, technology, activities, information and resources involved in moving a product or

service from supplier to customer (Markus, 2005). Supply chain can be divided into two, namely the external which refers to supply chain across all businesses within the whole supply chain and internal chain which refers to the chain across various departments within the organization.

The process of managing supply chain is called Supply Chain Management (SCM). Among those that puts it in a simplistic way is the one that says it is a systemic, strategic coordination of the usual way business runs. It entails tactics across these business functions both internally within the organization and externally across all businesses within the supply chain. The main purpose in SCM is to improve performance of the organization in particular and the whole supply chain in general. (Li *et al.*, 2004; Mentzer *et al.*, 2001). By having improved supply chain performance, an organization can be more resilient against the ever changing and challenging business or economic situation (Juttner & Maklan, 2011). Such an organization would be better off in its ability to cope with the consequences of unavoidable risk events in order to return to its original operations or even to a more desirable state after being improved upon (Christopher & Peck, 2004). This was echoed well by Ponomarov and Holcomb (2009), who said that "adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function". Calamities such as the tsunami in Japan (11th March 2011) are unavoidable disasters, but organizations that have established strong supply chain are able to overcome much better (Adenso-Diaz, Carlos, Mena, García-Carbajal & Liechty, 2012). This can be seen in the case of Toyota where even though the business was badly hit by the tsunami, it was able to bounce back (it was reported that vehicle production at various Toyota plants such as in Australia will return to normal levels earlier than expected after

production was reduced to 50 per cent after the Japan earthquake and tsunami) (Dang, 2012). In fact Toyota not only bounce back but it also was actively supporting other organizations (such as the organization in this case study which provides certain crucial parts to Toyota) that are hit so that the supply chain can be restored in the shortest possible time (Kurihara & Kono, 2011, Liker & Convis, 2012).

SCM is the integration of the various activities from the procurement of raw materials, transforming them into intermediate goods and final products and ultimately delivering them to customers (Heizer & Render, 2001). These activities include the normal purchasing function, and many other activities that are important to the relationship between suppliers and distributors (dealing with external parties) as well as within the organization's many departments or processes (dealing with the internal parties). SCM has drawn increasing attention from many practitioners and academics (Bechtel & Jayaram, 1997; Burgess *et al.*, 2006) due to the benefits evident in operational successes (Croom *et al.*, 2000). While interest in SCM is immense, it is clear that much of the knowledge about SCM resides in narrow functional silos such as purchasing and logistics (Burgess *et al.*, 2006). It is important to explore the great potential that exist in the other functions such as the internal supply chain in the manufacturing plant where the goods are being transformed from raw material to finished goods. Much non-value added activities does exist which when reduced or eliminated via strategies such as lean practices, would strengthen the internal supply chain and therefore improve the whole supply chain in general. It is a norm to find cases where the non-value (waste) added activities in the internal supply chain exceeds 50% of total activity time (Womack & Jones, 2005) and as such it hold lots of potential for improvement.

Another way to express SCM is that it is the management of a set of connected business dealings or processes with purpose of providing the end customers with the desired products and services (Harland, 1997). It cannot be denied that SCM applies to a total system approach to managing raw materials, work in progress, finished goods, information and services from supplier to production and to the customers (Chase, Aquilano, Jacobs, 2001; Rai, 2006; Stevenson, 2007). It involves customers, suppliers, manufacturers and distributors (Lee, 2000). A good SCM ensures the efficient execution of these activities so that the supply chain is kept in good state. However it has to be noted that the bottom-line in any business is important, and that is to make profit. By improving the supply chain the organization need to do it in such a way that ultimately it brings down the cost of its products or services.

The supply c+hain of an organization can be made clear visually through tools such a Value Stream Mapping (VSM) where the material and information flow are drawn. In the work by Singh and Sharma (2009), at a case site in India (producing sophisticated processed components to meet the need of diesel traction fleet of Indian railways) they explained how important VSM is in being a helpful tool for lean implementation. The tool is able to make clear the existing state of the supply chain (giving such information as % of value-add in the supply chain) and the proposed state. Road map to tackle improvement areas to bridge the gap between the two states can thus be generated.

From the VSM study, effort would then be made to remove non-value added processes (Rother & Shook, 1999). Since every organization is unique it is thus necessary to study each individually. As an example a study carried out in India (Punjab) reveals that for a particularly organization it was able to identify through tools such as VSM the non value added components and how it could be improved (Singh,

Garg, Sharma & Chandandeep, 2010). The findings however are limited due to the focused nature of the case, thus making generalization difficult or impossible. It is thus necessary for more cases to be studied so as to strengthen existing findings (or to dispute them) since a case study is an empirical inquiry investigating problems as they occur in the settings in which things happen (Yin, 2003).

As firms strive to increase their competitiveness in this challenging business world (via product customization, high quality, cost reduction and speed-to-market) they place more emphasis on the supply chain, thus the importance of SCM. To illustrate this point, a group of researchers conducted a study in Hong Kong among the manufacturers there. They strive to examine the importance of SCM and from there the success factors so as to ultimately reduce cost and improve the customer service level. Based on the research done it was found that organizations practicing SCM achieve positive results in term of cost reduction, lead-time reduction, improving customer satisfaction and competitiveness (Chin, *et al.*, 2004). However such studies cannot be generalized as the scenario is unique for the particular situation, location and condition. This spurs the need for more cases to be studied.

For the academics SCM is an important discipline that is acknowledged (Cousins, Lawson & Squire, 2006) while the practitioners sees the positive impact it creates in their bottom line such as how their supply chain improves due to improved material and information flow (Kaipia, 2009). Clear performance measurement is needed in enabling organizations to make judgment as to the state of its supply chain. This is important as there is always a danger of making wrong judgment due to the complexity in today's business environment.

In today's global market many organizations have come to realize quality product is not enough by itself. A firm must get the product to its customers when, where, and how they want it, and in the quantity they want at minimal cost. As such it is not surprising to see many organizations striving to implement SCM in order to stay relevant. Implementation of SCM takes many forms depending on whether it is the external or internal chain. In the case of the research in Hong Kong as mentioned earlier, the implementation of SCM has much to do with information technology. It was found that the most common tool used in the implementation are "faxes" and "e-mails" while some (though not many) utilized intranet, Enterprise Resources Planning (ERP) and software systems (Chin *et al.*, 2004). By utilizing such technology the competiveness of the organization is enhanced though at a cost which the firm has to consider.

In the implementation of SCM previous studies did highlight some issues pertaining to the complexities faced by the organizations. These complexities arose from the standpoint of scenario, interdependency, process and information or communication flow (Li, Kumar & Lim, 2002). To counter these issues, the organizations strived to review existing supply chain methods, by identifying the limitations of the methods. Indeed implementation of supply chain management requires a strong focus to improve in all functional areas, including sourcing, manufacturing, and distribution. It was found that firms which have a strong focus to improve their supply chain, records high levels of performance (Richey, Chen, Upreti, Fawcett & Adams, 2009).

These findings are important as it will enable practitioners to avoid certain pit-falls and improve the likelihood of success through the historical experience of others. As for the academics these add on to the emerging field of SCM, which also has become more prominent in the academic circle (Storey, Emberson, Godsell & Harrison, 2006).

Nevertheless the effort put in to improve the supply chain should be wisely channeled to relevant areas which suit the circumstances and environment.

2.2.1 The Relationship of Internal and External Supply Chain

A global phenomenon that can be seen is the way companies large and small alike are seeking competitive advantage through supply chain improvement both within and without the companies. This is done simultaneously as they apply new strategies and management techniques backed by the latest information technology (Boubekri, 2001)

Supply chain can be divided into two main parts, namely the internal supply chain and the external supply chain. Emphasis in SCM often concentrates on the external chain as can be seen by the various studies (Juste & Fierro, 2009). Nevertheless attempts to focus on how to improve the internal chain can be seen in isolated cases such as the one on developing a supply chain performance tool to measure the internal supply chain activities in SMEs located in Thailand (Banomyong & Supatn, 2011). Findings from such cases however are most of the time inappropriate for adoption due to factors such as being too wide in its scope (example this research focus on SMEs in Thailand) as well as the fact that the industry it focuses on is rather narrow (example this research focus on the textile and clothing industry).

Supply chain management should concentrate on both the internal and external chain in order to reap the greater benefit. This was advocated in a research by Elmuti, Minnis & Abebe, (2008) where they showed positive and substantial improvements in overall performance as a result of integration and coordination of the internal chain (functions within the firm) and effectively linking them with their external suppliers. It

was found that there was a positive relationship between internal and external chain, in the area of collaborative forecasting and planning. Key contributors to the success of the firm was attributed to sharing information through new technologies, established partnerships with main suppliers, and constant communication with employees.

2.2.2 External Supply Chain

External Supply Chain would involve how the organization deals with its interested parties such as suppliers (upstream) and its customers (downstream), (Quesada, Rachamadugu, Gonzalez & Martinez, 2008). It can be seen that most SCM research focus on the external chain (Juste & Fierro, 2009). In fact most lay people would view SCM solely from the standpoint of its external chain only. Through the years the strength of the external chain has been growing and it is undeniable that much progress can be seen.

In order that the external chain functions effectively, the external information flow between all interested parties is of utmost importance. External information flow would be the information flow between people who work for the company and people who don't work for that company or organization (i.e. outsiders involving the suppliers as well as customers). The result of the continuous improvement in the external chain can be seen in developments such as the innovative Vendor Managed Inventory (VMI) (Sari, 2007), where adoption of this is spreading in various places and industries (Borade & Bansod, 2010; Tanskanen, Holmstrom, Elfving & Talvitie, 2009). This business model has impacted the way business runs in this generation. Basically it involves the supplier taking full responsibility for providing an agreed level of inventory (material) for the buyer at an agreed location (normally in the buyer's site).

Through advance information technology such as Enterprise Resource Planning, the mechanism for effective communication which is a key factor for the smooth implementation of VMI has been put in place and most advance organizations subscribe to this practice (Danese, 2006).

This integration with suppliers can indeed enable the organization to respond more aggressively especially in the face of volatile demand (Sun & Ni, 2012). To achieve this there will need to be an increased information visibility (which is part of visual management) and operational knowledge (Kim, 2006a). By so doing the end result could be a decrease in cost of doing business, apart from the price reduction to the customers (Swink, Narasimhan & Wang, 2007). From the perspective of new product development, the benefit would be extensive reduction in time to market the new product, cost reduction, customer satisfaction and reduced quality problems among others (Takeishi, 2001).

It is well said that the strength of a chain is determined by the weakest point which in an organization's supply chain could be the upstream or downstream network. This concept is put forward in the theory of constraint (Goldratt, 1990). With this in mind it is thus important to strengthen the supply chain from the view point of the whole supply chain. This means that if the weakest point is at the internal chain then it is most appropriate to focus on how it can be strengthened there so that ultimately the whole chain is strengthened. Generally in terms of attention given in research, there is an ever increasing emphasis on the external supply chain (networking outside the boundaries of the organization) and a lack of emphasis on the internal supply chain of which this paper aims to focus on (Sundram *et al.*, 2011)

2.2.3 Internal Supply Chain

Just as the external chain was defined as dealing with the external parties, the internal chain refers to interested parties within the organization. It is related to the internal aspects (Lee, Kwon & Severance, 2007). This consists of all functions within the organization such as production, maintenance, quality, human resource, accounting, engineering, etc. In the work by Chen and Paulraj (2004a) they illustrates the relationship of a company's supply chain where specifically the internal supply chain was described. Internal supply chain can be across departments such as Purchasing, Human Resource and Finance or it can be within the production line itself which can be from one production process to another (such as from bonding to molding and cutting etc). Emphasis on internal supply chain research can be seen in studies such as the one on future research direction for supply chain (Dittmann, Stank & Autry, 2011) and those that talks about how the use of information and communication technology (ICT) such as enterprise resources planning (ERP) should be deployed in a small and medium sized manufacturing environment compared to a large corporations (Huin, Luong & Abhary, 2002). In the work by Huin *et al.* (2002), they highlighted the lack of study into the knowledge gap faced by organizations of differing sizes in the implementation of the ERP system. The knowledge level (both from the aspect of education as well as experience) required in each organization would be contingent upon their size (example it is expected that for successful ERP implementation in big organizations they knowledge level required would be more than those of smaller organizational size).

Parties involved in the internal chain basically are related to the function they play in the supply chain (Chopra & Meindl, 2004). For example those related to the production function could be engineering staffs, production operators, supervisors,

managers, quality inspectors etc.. In some organizations the parties are categorized into two main groups, namely the direct staffs such as operators, inspectors, line-leaders etc. and the indirect staffs who are those such as supervisors, managers etc.

Traditionally, in the internal supply chain, the marketing staffs undertake certain roles such as understanding and representing customer needs to the different company departments. This traditional thinking however is not relevant today. In fact now it is expected that every functional area can interact with customers, especially electronically (Kotler & Armstrong, 2001). Though the active parties are as mentioned earlier on, it is not uncommon to have the external parties dealing direct with the internal members especially in today's well-connected world. As such the active parties in the internal chain (all the personnel within the organization) are all in a sense linked to the external chain too.

In a study on Internal Supply Chain for a health care implementation in USA, it was found that only a small percentage of employees have direct contact with the external customers (external supply chain). This is despite the fact that the performance of virtually all of the employees affects the outcome of the external supply chain. While performance measures based on the firm's direct contacts with the external supply chain are critically important, the ultimate satisfaction of external customer are greatly influenced by what is happening in the internal supply chain. The "internal supply chain" must be clearly understood, carefully managed, and its importance cannot be downplayed (Swinehart & Smith, 2005).

As we enter or rather as we are in an "age of information", an area that is much related to the internal supply chain is communication. It is not only verbal or non-verbal

but covers the issue of communication ethics of which managers of today would need to be aware of. A wise manager should be well aware of this matter in their specific environment when they make decisions and communicate them (Beckett, 2003).

In a sense the external supply chain is never broken from the internal supply chain at any one time. This is because what is happening within in the internal supply chain will affect what the organization communicates externally. For example when it comes to the decision on when to begin a job order, the internal supply chain need to be confirmed through some well established communication channels such as whether there is sufficient inventory, labor, equipment etc. (Krumwiede, Tokle, Vokurka & Hackert, 2009). Many organizations (especially Multi National Corporations (MNC)) are linked to their external supply chain for both suppliers as well as customers via business-to-business electronic marketplaces (EMPs) as it brings about improved efficiencies and reduced cost in the supply chain. However in order to do so the fundamental is to establish within the organization the infrastructure such as having an enterprise resource planning (ERP) system in place.

2.3 Internal Supply Chain Performance

Although many different ways to measure performance of SCM exist, such as integration (Devaraj, Krajewski & Wei, 2007), cost effectiveness (Hitt, Keats & Demarie, 1998), inventory level (Holmberg, 2000), throughput efficiency (Milgate, 2001), flexibility (Ndubisi, Jantan, Hing & Ayub, 2005), information and material flow (Bhagwat & Sharma, 2007) and delivery performance (Stewart, 1995) research points to the need for more studies (Beamon, 1999; Holmberg, 2000; Morgan, 2004). One example is in the study by Beamon (1999), where he argues that measuring SCM

performance should include some guidelines. The guidelines mention three measurement which are a) resources measurement (Efficiency), b) Output measurement (Customer Satisfaction) and c) Flexibility (how well the system reacts to uncertainty). Li (2002) gave his view that different researches have attempted to assess SCM performance in different ways, but most measures it more from the economic stand point rather than the customer satisfaction which was advocated by Harland (1996).

Among the many attempts to measure supply chain management performance, the more obvious ones came from the Supply Chain Council (SCC). The council developed the Supply-Chain Operations References (SCOR) model which came up with common process-oriented language for communicating among supply-chain partners (Lockamy & McCormack, 2004). The exploratory study dwell on the question of what were considered the most important SCM practices in the area of planning, sourcing, making and delivery. The measurement metrics as described by Lapide (2000) are focused on cycle time (example production cycle), Cost (example per shipment and cost per warehouse pick), service or quality (example on-time shipments and defective products and asset (example inventories).

Supply chain performance is defined as the overall efficiency and effectiveness of the supply chain (Beamon, 1999; Beamon 1998; Gunasekaran, Patel & Tirtiroglu, 2001; Kiefer & Novack, 1999; Spekman et al, 1998). Sundram *et al.*,(2011) defined it similarly as the set of activities undertaken in an organization to encourage effective management of its supply chain. It will be measured through supply chain flexibility, supply chain integration and customer responsiveness (Qrunfleh, 2010; Li, 2002). These 3 dimensions are intended to cover the performance measure as mentioned by Beamon

(1999) in the earlier paragraph. Table 2.1 provides a summary of the various literatures supporting the 3 dimensions.

Table 2.1
List of Literatures to Help Develop Dependant Variable

Dimensions	Definitions	Literature
Supply Chain Flexibility	Flexibility reflects an organization's ability to effectively adapt or respond to change that directly impacts an organization's customer	Aquilano, Chase & Davis, 1995; Aggarwal, 1997; Aslanertik, 2005; Butner, 2010; Duclos, Vokurka & Lummus, 2003; Kumar, Fantazy, Kumar & Boyle, 2006; Kumar & Kumar, 1988; Lau ,1996; Pujawan, 2004; Sanchez ,1995; Suarez, Cusumano & Fine, 1991; Swamidass & Newell, 1987 ; Vickery, Calantone & Droge, 1999
Supply Chain Integration	The extend of all activities within an organization, and the activities of its supply chain members being integrated together.	Aryee, Naim & Lalwani, 2008; Frohlich & Westbrook, 2001; Kim, Cavusgil & Calantone, 2006; Kim, 2006b; Lee, 2000; Lummus & Vokurka, 1999; Mentzer *et al.* 2001; Narasimhan & Jayaram, 1998; Naslund & Hulthen, 2012; New, 1997; Power, 2005; Simchi-Levi, Kaminsky & Simchi-Levi, 2003; Stevens, 1990; Stock, Greis, Kasarda, 1998; Sundram *et al.*,2011; Turner, 1993; Vickery, Jayaram, Droge & Calantone, 2003
Customer Responsiveness	The speed of an organization's responses to the customer requests.	Beamon, 1998; Chen & Paulraj, 2004(b); Daugherty, Ellinger & Rogers, 1995; Gunasekaran & Ngai, 2003; Handfield & Nichols, 2002; Hitt *et al.*, 1998; Krause, Handfield & Scannell, 1998; Lee & Billington, 1992; Mehta, 2001; Monckza & Morgan, 2000; Owens & Richmond, 1995; Pehrsson, 2011; Pagell, 2004; Schlegelmilch & Ambos, 2004 ; Tunc & Gupta, 1993; Zhang, Vonderembse & Lim, 2003

2.3.1 Supply Chain Flexibility

For an organization to perform, it would need to understand the customer's needs and respond to it. Customer's request comes in various forms such as quality, pricing, turn-around-time etc. In fact customers today are demanding more variety, better quality and service, including reliability and faster delivery. With new technological developments occurring at a faster pace, new product innovations and improvements in manufacturing processes can be expected to occur more frequently (Duclos *et al.*, 2003). The flexibility should be both in the delivery time as well as flexibility of product delivery time (Aquilano *et al.*, 1995). These are all essential so that the competitive advantage can be maintained or enhanced. It is well said that companies need to be flexible enough to react to changes in customer's demands (Aggarwal, 1997). Though flexibility is sort after by all organizations, one has to be conscious of the cost of having flexibility (Aslanertik, 2005). For instance in order that a particular production line can be flexible in running a diverse range of products depending on the customer's request, additional features would need to be designed into it and this will definitely come with a price tag. As such though flexibility is much desired, there is the balance that management needs to weigh with regard to the cost of flexibility. This is because there is the issue or possibility of the cost-containment in supply chains not being able to keep pace with cost volatility (Butner, 2010).

The way to measure supply chain flexibility can be carried out in different dimensions such as, a) product flexibility or the ability to customize the product to match specific customer demand, b) volume flexibility or the ability to change production capacity to meet changes in customer quantities, c) new product flexibility or the ability to implement new revised products; d) distribution flexibility or the

ability to make available the products in a widespread way, e) responsiveness flexibility or the ability to heed changes in the target segment (Vickery *et al.*, 1999).

In order for the organization to be on the cutting edge in term of supply chain flexibility, it need to be intimate with the customer so as to know their needs such as their specific specifications, market behavior, product demand trend (such as whether it is seasonal or not), life span of product etc. This better connectivity with the customers will be useful inputs even for the internal supply chain as the members working there will know what adds value to customers and what doesn't (Butner, 2010). By being so sensitive to the customer's need the organization can thus make appropriate decisions that are value added. Despite the need for supply chain flexibility the overzealous effort of some organizations to create agility in respond to the ever uncertain environment and severe customer request (both for quality and quantity), it often leads to complexity which often time is counter-productive (Prater, Biehl & Smith, 2001).

In this study, supply chain flexibility is defined as the ability to effectively adapt or respond to changes that directly impact an organization's customer. Previous studies commented on the need to undertake more empirical research in this field (Vickery *et al.*, 1999; Kumar *et al.*, 2006). Flexibility includes areas such as in machine, material handling, operations, automation, labor, process, routing, product, new design, delivery, volume, expansion, program, production and market flexibility (Duclos *et al.*, 2003). Among some highlights from previous studies pertaining to supply chain flexibility are, that it is an effective strategy to address uncertainty (Swamidass & Newell, 1987), for each type of uncertainty it in turn requires a different and particular type of flexibility to accommodate it (Kumar & Kumar, 1988), ICT and organizational structure are essential enablers to achieve the result sort (Sethi & Sethi, 1990) and, importance of non

technical means in achieving the flexibility (Suarez *et al.*, 1991). It was said that in order for a firm to gain and maintain its competitive advantage in a dynamic environment, it is necessary to create a flexible organization (Sanchez, 1995). By this it meant resource flexibility (the extent to which resource can be applied to a range of alternative uses) and coordination flexibility (flexibility in those processes that redefine product strategies, reconfigure chain of resources to produce and re-deploy those resources). This idea by Sanchez (1995) is supported by Lau (1996), who defines supply chain flexibility as a firm's ability to respond to uncertainties by adjusting its objectives with the support of its superior knowledge and capabilities. In the paper by Kocakulah, Austill and Schenk (2011), they gave an example of supply chain flexibility in the case study site where the manufacturing line was able to achieve flexibility to the extent that a particular type of model can be produced next to a different model – specifically, different types of brands, colors, features and product sizes. The end result is it gives the said organization a competitive advantage.

Though in general there is an understanding that supply chain flexibility is desired, such as the ability to switch suppliers when there is a shortage, or the ability to quickly increase production of a high demand model through converting more machineries (which are designed to be flexible), there is the negative aspect such as having to increase the cost of production for being flexible (such as foregoing the benefit of lower cost due to large quantity purchase), or the increased complexity in planning due to the flexibility built in (Pujawan, 2004).

2.3.2 Supply Chain Integration

Supply Chain Integration deals with the extent to which all the activities within an organization, suppliers, and customers are integrated together (Stevens, 1990; Stock *et al.*, 1998; Stock, Greis & Kasarda, 2000; Narasimhan & Jayaram, 1998). The integration requires effective communication among all members of the supply chain (Turner, 1993) such as in the virtual enterprise e-supply chains used by fabless semiconductor companies (Cesar, 2004). It is by doing so that the improved synergy through integration could bring about more competitive advantage to the organization. The work by Sundram *et al.*, (2011) agrees with this when they reported that in order to be highly competitive (to achieve sustainable profitability growth), SCM seeks close integration of internal functions within the firm. To achieve this there is a necessity to have an effective construction of practices in the supply chain (Kim, 2006b). Research however also reveals that most companies are still grappling with the internal process integration (internal supply chain) with very few achieving closer integration with their customers (Aryee *et al.*, 2008). Interestingly the research also gave insight into the prominence of "soft" collaborative issues rather than the "hard" technological issues in the integration drive. In another research the authors concur with what was said by their findings which shows limited empirical research on the matter of Supply Chain Integration and the claimed benefits of adopting it (Naslund & Hulthen, 2012). They also revealed that there is significant confusion regarding the term supply chain integration. Recent work by Sundram *et al.* (2011) commented quite clearly that in the corporate world, in order to meet customer requirement, the integration of various business processes such as planning and forecasting, procurement, manufacturing, distribution etc (effective and efficient management of flow of resources from point of

origin to point of destination) has become important parts of SCM (Lummus & Vokurka, 1999; Mentzer *et al.*, 2001; New, 1997).

Supply Chain Integration covers issues relating to integration of core processes through improved communication, partnership, alliances and cooperation (Power, 2005). The notion of leveraging linkages within the supply chain is not new and can be traced to Porter's value chain model which showed the importance of exploiting both intra and inter firm linkages (Porter & Miller, 1985). In recent time however, interest (both practitioners and academics) has been more intense as firms seek to establish a competitive advantage in an increasingly competitive, dynamic global marketplace.

Stock *et al.* (1998) gave their view that there are two kinds of integration: a) internal integration which reflects the extent to which activities interact with other functions areas or processes and b) external integration, which reflects the integration of logistics activities across firm boundaries that include suppliers and customers or the external supply chain. Integration deals with sharing resources, risk, and knowledge between supply chain partners (Kim *et al.*, 2006). To further explain, Frohlich and Westbrook (2001) put forth their view that integration involves coordinating and integrating the forward physical flow of deliveries or products between suppliers, manufacturers, and customers. They add on that integration also involves the backward coordination of information technologies and the flow of data from customers, to manufacturers, to suppliers.

Lee (2000) proposed some key dimensions which constitute supply chain integration. These are a) information integration which refers to the sharing of

information and knowledge among members of the supply chain i.e. demand information, inventory status, and capacity plans, b) coordination which refers to the redeployment of decision-making authority, work, and resources to the best-position in the supply chain such as letting other suppliers replenish their inventory, and c) organizational linkage which means strong organizational relationships with suppliers such as joint performance measures.

Supply chain integration can provide an organization with the opportunity to focus on its core competencies and particular areas of expertise (Simchi-Levi *et al.*, 2003). It will also lead to the strengthening of key resources and enable the sharing of special resources and technological knowledge between the firm and its supply chain partners, (Vickery *et al.*, 2003). Such integration will help supply chains to reduce costs and be more efficient, as well as create value for the company, its supply chain partners, and its shareholders (Lee, 2000).

On a negative note, supply chain integration may also result in setbacks such as deterioration of quality (due to number of process owners reduced). It is important to be able to identify under what circumstances the integration brings positive outcomes and when it is otherwise. Towards this end there are case studies which attempt to study the effect of supply chain integration such as the one by Trkman and Groznik (2006) in the field petrol industry. As such more studies in differing industries would need to be conducted.

2.3.3 **Customer Responsiveness**

Owens and Richmond (1995) suggest that achieving customer responsiveness involves the entire supply chain. They explain that the overall objectives of an organization's supply chain management should be, to become increasingly responsive to customer needs, and to create value for the customer. Various approaches such as implementing lean practices have been found effective in satisfying the customer request and at the same time preserving or even enhancing the profitability of the business (Liker & Franz, 2011). The performance or effectiveness of the supply chain must be measured by its responsiveness to customers (Lee & Billington, 1992). However there is always the real potential of being over sensitive towards the customer's request which ultimately would encroach into the profit of a business. Pehrsson (2011) shows in his work that one has to judge and balance up on being customer responsive and being volume focused. He concluded that a firm (at least in the context of Swedish firms since the research was carried out there) may find an efficient customer responsiveness being more critical in a growing market (such as clean technology markets) situation compared to a mature market (miscellaneous market). This is in line with the contingency approach which suggests a fit between customer responsiveness and the market context (Peteraf & Reed, 2007).

Changes in customers' operating systems due to forces shaping competition are among the reasons why there is a need to work more closely with them. The markets in which manufacturers compete are increasingly affected by intense competition, rapid technological changes, shorter product life-cycles etc (Krause *et al.*, 1998; Hitt *et al.*, 1998; Zhang *et al.*, 2003). This is why organizations need to recognize the changing environment by being more responsive (Daugherty *et al.*, 1995).

Customer responsiveness is strongly linked to information, in which appropriate use of it is essential. The modern day customers (Handfield & Nichols, 2002) are those expects greater responsiveness to an ever changing set of requirements, and a new competitive environment (Bower and Hout, 1988; Stalk, 1988), which exposes most companies to competition internationally and form a new situation that has challenged firms in most industries (Mehta, 2001; Monckza and Morgan, 2000; Pagell, 2004). To justify this argument, Daugherty *et al.* (1995) conducted an empirical study to explore the relationship between information availability and customer responsiveness. The result of their study suggest that information availability and customer responsiveness are positively related which resulted in improving firm performance. Despite this finding it has to be noted that the infrastructure in that organization need to be in place in order for it to take advantage of the information available. Inefficient processes need to be reengineered so as to make it more efficient from the business point of view, even if it means to use new technology (Awad & Nassar, 2010). However in the process, caution must be taken to avoid overzealous spending on technology to improve the supply chain performance as there are many disappointed firms who learnt the hard way (Lockamy & McCormack, 2004).

Customer responsiveness should include value add activities such as customized services (Schlegelmilch & Ambos, 2004). This could take the form of committing to a short order-to-delivery cycle time even at the expense of having to reduce batch size. Having said this any business organization would want to make sure that their strategy brings tangible benefits. Wee and Wu (2009) defined it well when they said that value add activities (both tangible and intangible) are those that customers are willing to pay

money for. This in general would be a good guideline for those having difficulty in categorizing value add and non-value adds activities.

Customer responsiveness is defined as a firm's ability to respond in a timely manner to customers' needs and wants (Tunc & Gupta, 1993; Chen & Paulraj, 2004b) as well as responsiveness to changing market requirements (Gunasekaran & Ngai, 2003). In organizations while implementing lean, the practices adopted often time will have impact on the internal supply chain such as in the area of customer responsiveness, measured by KPIs such as lead time, total response time etc (Beamon, 1998).

2.4 Lean Manufacturing

Lean manufacturing has potential of improving many aspects of an organization. Among them are throughput, reducing costs, quality improvement, wasteful tasks, and delivering shipment with shorter lead times (Cudney & Elrod, 2011). Hines (1996), put forth his view that lean initiatives would benefit the organization, through decreased inventories by sharing sales forecast or production schedule, improved quality and knowledge through co-designing of products which will lead to more stable supply prices by committing long-term partnership. Today, manufacturers face with even more complex and longer supply chains than before. By implementing lean manufacturing an organization concerns itself with how it could improve its entire supply chain (Oliver, Delbridge & Lowe, 1993), both internal as well as external. Through lean principles the organization can further leverage the supply chain's competitiveness with increased responsiveness to changes in demand and reduced costs (Oliver *et al.*, 1993, Ryan, 2001).

Christopher (1998) stressed that though leading-edge companies seek to make supply chains more competitive as a whole by which adding values and reducing cost (through activities such as integrating internal business functions of the companies) are carried out, it is essentially insufficient. Many organizations have attempted lean practices, but not all have succeeded in implementing it correctly and thus did not benefit in its supply chain (Cudney & Elrod, 2011). Nevertheless to appreciate the lean initiatives one has to go back to history.

The concepts of lean manufacturing started way before Toyota practiced it. The root of this concept can be traced to Ford automobile manufacturers as traced by Holweg (2007) in his work on "The genealogy of Lean Production". It was there that the concept was used even in the manufacturing of the famous model T automobile. In that plant, Henry Ford started to practice ideas such as continuous assembly lines, and flow systems. These are important lean concepts even in this modern time. In fact there are more concepts developed such as pull production, kanbans, batch-size reduction, kaizen activities, quality circles etc (Ahls, 2001).

In Japan the lean manufacturing concept took on a more successful mode compared to the United States (Emiliani, 2006). It was here that the Toyoda family, shifted from their textile business to automobile. After World War II, the automobile industry in Japan faces a tough market. This is due to their rather small and diversified market. Players like Ford outperformed the small players such as Toyota.

It was under such trying times that Toyota was tasked with making a system that will stand the competition. The man, who made a difference, was Taichii Ohno. He

together with his colleagues created a system called Toyota Production System (TPS). All in all the system developed through three decades and was influenced by famous people like Juran and Deming. It was through implementing TPS that the company was able to overcome the adverse business situation until today (Holweg, 2007).

2.4.1 Philosophy

The term "Lean Manufacturing" was made famous by Womack *et al.* (1990) and is being widely used nowadays. Even though lean manufacturing is most commonly practiced in the automobile industry (Krafcik, 1988; Shingo 1981), the philosophy has of late spread to non-automobile industries.

Lean is also pursued not only in manufacturing but also has shown positive results in administration and customer service. In essence lean manufacturing is primary about elimination of waste or what is commonly called in Japanese as "muda". A simple way to summarize waste is it is something that consumes resources but does not add any value to the product (Singh & Sharma, 2009). Schonberger (2007) introduces three categories of waste typically found in manufacturing plants which are,

(1) Muri, meaning excess, producing more than is required.

(2) Muda, meaning waste, in all of its forms.

(3) Mura, unevenness, materials parts and goods should all flow at an even rate and not fluctuate. This concur with Sayer and Williams (2007) who further elaborate on the not so commonly known "mura" and "muri" :

a) "Mura" which mean unevenness. Mura is variation in an operation when activities don't go smoothly or consistently. This is waste caused by

variation in quality, cost, or delivery. Mura consist of all the resources that are wasted when quality cannot be predicted. This is the cost of testing, inspection, containment, rework, returns, overtime, and unscheduled travel to the customer.

b) Muri which mean overdoing or the unnecessary or unreasonable overburdening of people, equipment, or systems by demands that exceed capacity. From a lean perspective, muri applies to how work and tasks are designed. One of the core tenets of lean is respect for people. If a company is asking its people to repeatedly do movements that are wasteful, then the company is not respecting the people. There is a need to perform ergonomic evaluations of operations to identify movements that are either harmful or unnecessary.

The famous Toyota "7 muda or 7-Waste" (Ohno, 1988; Womack & Jones, 1996; Monden, 1998; Liker, 2004; Wee & Wu, 2009) are:

i) Over production

ii) Excess inventory

iii) Unnecessary conveyance or transportation

iv) Defects or correction such as repair

v) Extra processing or over processing

vi) Motion such as unnecessary movement

vii) Waiting or delay

In some literatures, there is a proposal for an 8th waste. That is "Waste of Unused employee creativity" (Liker, 2004). It is losing time, ideas, skills, improvements, and

learning opportunities by not engaging or listening to your employees. The following elaborates more on these waste advocated by Liker (2004), Imai (2001), Womack *et al.* (1990) , Emiliani (1998) and many others.

Waste of over production. This waste occurs when manufacturing, assembling or building more than what is needed. There is always a tendency to produce "Just-In-Case" to counter various source of uncertainty in production flow. Inaccurate scheduling too creates over production compared to customer demand. Long lead times and long change over times, results in tendency to make large batch of production that may be more than what subsequent processes need. Not being closed enough to customer (or next process) to understand their changing needs, leads us to longer production runs. This concur with Khanna and Shankar (2008), who commented that over production is regarded as the most serious waste as it discourages a smooth flow of goods or services and is likely to hinder quality and productivity. Apart from these over production also tend to lead to excessive lead time and storage time.

Waste of excess inventory. Producing more than what the customer wants by any operation in the manufacturing processes, necessarily leads to a build-up of inventory somewhere downstream. That is to say material is just sitting around waiting to be processed in the next operation. So, what's the problem then especially when people and equipment are in operation? The problem is that big buffers (inventory between processes) lead to other sub-optimal behavior, like reducing motivation to continuously improve the operations. There is also no worry about preventive maintenance on equipment when shutdowns do not immediately affect final assembly. This is how high inventory hides process or equipment reliability problems. Mortimer (2006) illustrates this well in his paper on how WIP was reduced in a United Kingdom electronic firm

with positive result. When there are few quality errors there is no concern since one can just toss out defective parts. These are such sub-optimal behaviors. Moreover, when inventory level is high, by the time a defective parts arrive at the assembly operation, there may be weeks of bad parts in process and sitting in buffers. Excess inventory also results in more capital being held up as unfinished goods or goods in warehouse and resulting in loss opportunity for other investment. In some industries, piled up inventories are positive, but in almost all, or the majority of manufacturing firms, inventories should be kept controlled because cost of the products are affected by the increased inventories. It is for this reason that in lean continuous material flow is being sort after so that there will not be this waste of excess inventory (Towill, 2010).

Waste of unnecessary conveyance or transportation. This waste occurs when people, product, equipment or information are moved more often or further than needed. During multi step operation, people and product moves from one process to another separated by a distance. Instead of processes being sequential or positioned next to each other, they are far apart. It may require forklift, conveyors or other moving devices to reposition for the next step in a process. All these movements add no value to the product (Khanna & Shankar, 2008).

Waste of defects or correction. This occurs when there is lack of preventive systems such as error proofing techniques or preventive maintenance. Once a defect is created, it is not possible to deliver it to customer. Resource spent on it is not recovered. Even if it can be reworked and delivered to customer, the additional resources to do rework are not recovered. It is still a waste. Visual inspection work carried out to screen for defects created by automatic machines too is a waste, because both creation of defect and screening consumes resources that are not paid for or add values.

Waste of Over Processing. It is caused by making a product or service better than a customer need, or is willing to pay for. Adding features that are not value added from customer point of view, does not improve a product or process. Not closely monitoring how customers use our products or services, leads us to build in or provide features that we think they want or need without knowing for sure. Over processing increase expenses by putting up additional costs and expenses for processing materials and labor costs. Time is also wasted due to this.

Waste of unnecessary movement. This waste is the unnecessary movement of people, product or equipment that adds no value to a process. Worker walk away from work area to storage rack, walks around idle equipment or perform redundant motions that can be eliminated to speed up the process. The loss time and production time, takes away opportunity to function more efficiently and also makes employee work effectively. This is even harder to identify when work is not manual but rather using automatic machines. However, each unnecessary motion still deprives an opportunity for a value adding motion (Towill, 2010). In order to reduce this waste of unnecessary movement, industrial engineers typically would seek to eliminate "waste time" and "waste motion" through time and motion study (Suzaki, 1987).

Waste of waiting or delay. Waiting waste comes from idling worker, processes or partially finished goods while waiting for instructions, information or raw materials or in queue. Poor scheduling, poor vendor support or communications and inaccurate inventories cause processes and people to come to a halt and cost us valuable time and profit.

In the book "The Toyota Way" (Liker, 2004), Fujio Cho, President of Toyota Motor Corporation emphasized the need to make it a daily practice to reduce waste or "muda" as this was what makes Toyota stand out compared to other automobile companies. In the process of reducing "muda" Sayer and Williams (2007) further categorize them to Type-1 muda and Type-2 muda. Type-1 muda consist of actions that are non-value added, but are for some reason judged necessary for the organization. These forms of waste usually cannot be eliminated immediately. As for Type-2 muda, they are activities that are non value added and are also deemed as not necessary for the organization. This type of muda is normally the first target for elimination. In a sense this categorization is quite similar to Monden (1993) and Bicheno (1991) who puts it as non-value adding (NVA) and necessary but non-value adding (NNVA). Examples of NVA or Type-2 muda are such as waiting time, stacking intermediate products and double handling (Hines & Rich, 1997). As for NNVA or Type-1 muda they are like walking long distances to pick up parts, unpacking deliveries, transferring a tool from one hand to another etc.

Indeed lean results in improved output and quality levels, and achieves this using fewer resources, such as raw materials and employee effort (Boyle & Rathje, 2009). This is in line with adding value (defined as what the customer is willing to pay for) to the customer. It is well said that lean is a management philosophy that concentrates on not only identifying the non-value added task (waste) but also more importantly eliminating it. This process when carried out in the entire value stream of the supply chain will result in tremendous improvement (Shah & Ward, 2007; Liker, 2004).

2.4.2 Outcome in Implementing Lean

Why do organizations spend so much resource to achieve lean manufacturing status? Based on the basics of lean manufacturing, the philosophy stresses the need to continuously improve in the area of waste reduction in all its processes or supply chain. Through the elimination of waste the most obvious benefits is the improved efficiency in its operation or supply chain (Gibbon & Burgess, 2010).

An organization that practices lean manufacturing philosophy in essence is one, which utilizes constraint management. Constraint Management is a process of continuous improvement whereby focus is given to areas of constraint or bottleneck. It is when we focus and improve the bottleneck that the actual productivity improvement can be seen (in contrast to improving the productivity in a non bottleneck process). The wisdom in following this constraint management is the organization will benefit much (overall result improves) with less (resources only focus on the bottleneck). This concept initially was put forth by Goldratt and Cox (1992) in their book "The Goal".

With the implementation of lean manufacturing quality of the product will improve. In fact even if defects are made (due to practice of having minimal inventory), it will be less in quantity, thus reducing losses.

A major improvement that should be felt or seen is the improved space utilization when the organization implements lean concepts. This would be the result of adhering to the reduction in inventory as well as the cell concepts where machines would be layout in such a way that it would be closer to each other (thus reduce the waste of movement etc).

Safety is always given top priority in lean manufacturing. As such one can expect the work place to be a safer place with the implementation of lean (Kocakulah *et al.*, 2011). It is normal for organizations practicing lean to study every process or job and highlight areas that have safety concerns. In this way prior to having a machine being commissioned for mass production key safety issues that are highlighted will need to be addressed.

By virtue of practicing lean concepts such as minimum inventory, short turn-around-time, reduction of defects etc, the organization would be able to build a culture that is innovative. This is because there will be the consistent pressure to come up with solutions after solutions in a situation where there is just enough work in progress to sustain the line for a short period of time, reducing the processing time, improving the quality of products etc. Apart from this the principles practiced in lean concepts such as Just-in-Time (JIT) augurs well for simplified rapid flows of information (communication) and material (Alfnes & Strandhagen, 2000).

Cases of organizations benefiting from implementation of lean manufacturing abounds. Just to quote some cases, in a recent research astounding results in an organization situated at Patiala, Punjab (India) was documented. In that organization, production output per worker has improved to 3.20 from 2.24 products (an improvement of 43%). Production lead-time was reduced drastically from 22.44 to 3.78 days (more than 80% improvement) and Value Added (VA) time was also reduced from 4.2 to 3.67 hours (a 13% improvement). With the improvements made, the organization could easily meet its demand while achieving an enhanced bottom-line (Singh *et al.*, 2010).

In a real industrial case study of assembly line improvement by means of lean management, (Domingo, Alvarez, Pena & Calvo, 2007), result of reduced dock-to-dock time and lean rate shows improvement. This transformation of a manufacturing organization into a better lean organization that has attained lower cycle time seems to be a common phenomenon among many who have chosen to implement this philosophy. It was also acknowledged that every organization is unique and as such need to adapt the tools in lean manufacturing to its environment.

A research done in an Assembly Automation factory (United Kingdom electronic product manufacturing operation) found that the company was able to survive through its implementation of lean concepts. This was after having experienced high WIP and long lead-time. The introduction of lean where batch production were being replaced with flow has enabled the reduction of WIP and shortening of lead time (Mortimer, 2006)

Not only is the implementation of lean centered on manufacturing but even in the pure service industries. Successful implementation showed both improvements in quality and cost with minimal investment through adoption of lean tools in the pure service context (Piercy & Rich, 2009)

It is worth recognizing that in today's fast changing world, attempts to go beyond lean manufacturing are already underway. Agile manufacturing practices can be seen in some industries such as the specialty chemical industry (Guisinger & Ghorashi, 2004). Mass customization, which requires companies to provide personalized products and

services at mass production price, is also a common trend (Pham, Pham & Thomas, 2008).

Not all companies that adopt lean practices are successful. In fact it was reported that a large survey conducted by Industry Week in 2007 found that only a small percentage of companies that have a lean program achieved their anticipated results (Liker & Franz, 2011). Nevertheless in the pursuit of excellence companies have to do something if they are serious and the effect on how it affect their supply chain need to be evaluated on a case by case scenario. By adding on to the body of knowledge, such studies will provide useful insight to those who are aiming to improve their supply chain whether external or internal.

2.4.3 Lean Practices

Interest in the subject of lean is attributed to the writer of "The Machine that Changed the World" by Womack *et al.*, (1990). They highlighted the performance gap seen between Toyota (the Japanese car maker) and other carmakers. It is from here that the term "lean manufacturing" became famous especially in the 1980s and 1990s. There has been an overzealous tendency during that period in that some organizations were so enthusiastic for the lean methods to be introduced by assuming its superiority and non-rational criteria (Oliver, 2008).

Though there are many varieties of lean practices the actual implementation varies widely. There is an absence of a consensual lean practices list and this may present difficulties for academics as well as practitioners (Andersson, Eriksson & Torstensson, 2006 ; Pettersen ,2009). In fact Shah & Ward (2003) in his compilation of 16 articles

made a list of 22 practices of which there is none that adopt all the practices. Adoption of lean practices frequently depends upon organizational characteristics, and not all organizations can or should implement the same set of practices (Galbraith, 1977). This also concurs with the contingency theory as mentioned earlier.

Among the practices, the ones that are more prominent are cellular layout (Chan, Samson & Sohal, 1990; Sakakibara, Flynn, Schroeder & Morris, 1997; Koufteros, Vonderembse & Doll, 1998), 5S (Gapp, Fisher & Kobayashi, 2008; Cooper, Keith & Macro, 2007; Ginn & Finn, 2006; Hirano, 1995), Visual Management (Kocakulah *et al.*, 2011; Flynn, Schroeder & Flynn, 1999; Koufteros *et al.*, 1998) which includes use of Kanban, Teams (Hay, 1988; Piper & McLachlin, 1990, White, Pearson & Wilson, 1999) which includes self-directed work teams, cross functional teams) and Lean Organizational Structure (Patrickson, 1994; Alavi, 2003; Li, 2008).

2.4.3 .1 **Cellular Layout**

A common practice in lean implementation is the use of layout changes to improve communication and to reduce non-value added activities such as excessive walking. In a research on office layout, it was found that geometry of workspace has indeed an impact on communication patterns (Boutellier, Ullman, Schreiber & Naef, 2008). This however is not always the way as some studies shows positive result in lean implementation without having to modifying the layout. It was found that by improving the routing flexibility it could compensate for the more expensive and tedious option of layout change while achieving reduced stocks, work-in-process and dock-to-dock time (Domingo *et al.*, 2007).

In the paper by Mortimer (2006), he observed the drastic improvement by the UK based electronic firm when they implemented a cell layout. By balancing the workload and creating flow, significant amount of double handling, movement and wasted activities were reduced. In fact the change from a conventional layout to a cell layout in this case resulted in a 20% manpower reduction, 25 % output increase, 33% production floor space saving, and a 98% reduction in WIP.

From the experience of the author, change towards cellular layout often comes with a limitation of cost as well as space efficiency. These often would need considerable evaluation prior to implementation and its effect after implementation may also not match the desired effect initially envisaged. Layout change made in line with lean implementation takes into consideration not only the physical flow of the material, products and human but also the information flow too (Emiliani, 1998). In this respect the emphasis on flow line (such as having a cell layout where numerous processes are grouped into one work area) in contrast to the traditional job shop (where an area is often assigned to a single process) is expected to bring about better flow both physically as well as information wise. The improvement in information flow for work cells is obvious as workers mingle face to face in their work area and communication is free flowing. Passing on information within the cell is so much clearer too as the members are able to demonstrate the "real thing" (utilizing Gemba Kaizen to the fullest). Physical barriers such as having to communicate across glass partition, creates issues with communication. This in lean manufacturing can be reduced, as less physical partitioning will be planned in the layout following lean manufacturing implementation.

In areas where physical layout constraints exist such as not being able to place a machine at optimal position due to limitations of space, pillars, cost, size of machines

etc, use of ICT may become useful as it can complement the change. Software in the area of layout can eliminate much waste in simulation and definitely reduce the time required to derive options for preferred layout (Rawabdeh & Tahboub, 2006). This concur with Ranky (2007), who spelt out 18 principles in a lean implementation of which one states that design and simulation in the digital domain (meaning on the screen first), before anything is built on the factory floor should be practiced. Apart from this software technology could be utilized to enhance or overcome layout limitations. For example in the event a data entry terminal may not be physically located at the optimal location, the use of wireless technology to input data or even view data could be considered. Nevertheless in the quest for cellular layout, some cases may exist which actually impede the flow of material and information of which we will only know by either observing the actual situation or interviewing the shop-floor personnel.

2.4.3 .2 **5S**

5S is a necessary initiating point within lean management philosophies and is practiced widely especially so in Japanese organizations (Gapp *et al.*, 2008; Cooper *et al.*, 2007; Ginn & Finn, 2006). It is defined as the five dimensions (Worley, 2004) of workplace organization. The 5S are defined as sort (identify unnecessary equipment), straighten (arrange and label the area so all tools have a specified home), shine (clean the area and maintain equipment daily), standardize (establish guidelines and standards for the area), and sustain (maintain the established standards).

In the book "Gemba Kaizen" by Imai (2001), he put it in Japanese as "Seiri" (distinguish between what is necessary item and what is not. The later should than be discarded), "Seiton" (arranging all the remaining items in an orderly manner), "Seiso"

(keep the machines and work area clean), "Seiketsu" (extend the concept of cleanliness to oneself and practice the first three "S") and "Shitsuke" (build self-discipline and make 5S a habit by setting standards).

It became obvious that by practicing 5S, the workplace would become not only clean but orderly and efficient. This would lead to less necessity to verbally communicate as the visual aspect will lend to clear simple communication. When "Seiri" and "Seiton" is practiced, the cluttered workplace would almost overnight be transformed with sufficient space to work. Waste of looking for things would be reduced as the number of items or even machines are reduced (less choice to make, less chances of taking the wrong thing, less walking to find the right thing etc). Work enhancement would be evident as things are now arranged in a manner where minimal time would be required to assess the required item. Communication would become less a hassle as things are arranged at the allocated (and well indicated area) space, thus making it easier to describe a phenomenon.

The practice of "Seiso" would ensure that the work area is sparkling clean, making the environment conducive for work. This coupled with "Seiketsu" where the emphasis would be to influence each individual to adopt the good housekeeping principle, would result in a work culture that people in general would want to be in. As an organization the culture can be build through consistently "preaching" and practicing these principles ("Shitsuke"). At the end of the day the practice of 5S would have effect on communication in a positive way as mentioned above.

It is quite obvious that the practice of 5S is fundamental to lean implementation and much emphasis on this can be seen in practice. A well-organized workplace that is

clean, uncluttered and safe is also productive (Galsworth, 1997). Though in principle with 5S, we can expect positive implications on the internal supply chain, this may not be so in practice. There are many especially those who are new recruits who may be practicing a form of 5S, but do not understand its fundamentals. As such there may be cases where even though the personnel practice 5S the effect on the internal supply chain may not be positive. A survey of the personnel working in a particular area could reveal the actual situation (Lynch, 2005).

2.4.3 .3 **Visual Management**

The difference between an efficient firm and an inefficient one is that the environment in good firms promotes the concept of identifying and acting on problems without delay. This is done by visual controls through the use of practices such as 5S described earlier on (Hirano, 1995). Visual displays are used for various reasons from monitoring production and quality levels to identifying bins of parts from a distance (Kocakulah *et al.*, 2011).

For lean manufacturing visibility is one of the important elements to work on. Visibility identifies waste when it appears so that it can be eliminated (Lynch, 2005). In fact (Imai, 2001) in the book entitled "Gemba Kaizen" visual management is said to be an effective method to provide information in a clearly visible manner. In an article on how automotive industries achieve good success through visual factory management, the researcher attest to the power of using Visual Management in an organization (Ranky, 2007). Through activities such as having a way to visually communicate by using simple signals, (thus giving an immediate understanding) it helps the workers to quickly and with fewer errors obtain the needed information (Engum, 2009). Both

workers and managers can easily know the current state of operations (which also includes its targets). Through visual management the abnormality can be identified promptly. It can be said that in lean implementation visual management enhance the communication. This is achieved through making clear among other things the key performance indicators and other important items.

An important aspect of lean manufacturing implementation is the need to communicate the key performance indicators to the members working there. This is to ensure that at the end of the day there is a gain both financially and non-financially. In fact it was found that by measuring and making the KPI (non-financial KPI) known it help in the achievement of the lean implementation and subsequently the financial gain (Fullerton & Wempe, 2009). Towards this end a good visual management in the lean implementation would be essential.

Kanban (a form of non verbal communication where normally cards or some visual signal are used to prompt a need to produce or transport raw materials or partially finished products to the next stage in the manufacturing process) in lean manufacturing implementation has shown success in ensuring effective flow of information that translates to efficient replenishment of materials or parts. Interestingly, the Kanban system is a non-verbal information flow tool that works well in many lean implementations. This attest to visual management's strength as it improves the information flow primarily in the internal supply chain for replenishment of material and even parts. In Toyota, the birthplace of the famous TPS, it was found that the stress in the plant on automation has been given less emphasis especially after the 1980's. In fact more priority has been given to managing the manual component in car assembly, and the previously aggressive automation emphasis as a preferred strategy has been put

on hold (Coffey & Thornley, 2006). This interesting development also lends to the importance of information flow. With more emphasis on achieving standard manual work cycle the information flow becomes even more critical. Surprisingly the use of non verbal systems such as the practice of Kanban has resulted in better information flow though it is non verbal (Mortimer, 2008). Despite these claims some research paper highlighted the inflexibility of the Kanban system for firms that introduced lean (Cusumano, 1994; Schonberger & Knod, 1997)

In actual practice however visual management can be rather tedious especially when it entails the members involved to update information manually. There are cases where management would want to know the hourly progress and have it displayed on a big board where the workers would need to remember to update manually. Such tedious job can be counter effective and can affect the actual morale of the workers thus affecting the supply chain in a negative way. Options such as the use of ICT to display progress even up to real time can be carried out to offset the manual task of updating. Though from TPS point of view it is always good to implement the visual management on a manual mode (Liker, 2004), in today's generation this may not be easily accepted.

2.4.3 .4 **Teams**

In a research on lean manufacturing performance, (Fullerton & Wempe, 2009) it was found that shop-floor employee involvement is critical to ensure its successful implementation. This agrees with what was disclosed by Brandt (2007), where he stress the aspect of having involved and empowered employees as being crucial to the implementation of lean in many areas of manufacturing and business.The research by

Yeomans (2007), reveals that effective internal communication is among the key points towards achieving an environment where staffs are able to bring about encouragement or motivation to excel in ones job. With the good internal communication it also eliminates rumors and misunderstanding, which often leads to unwanted industrial actions.

Having teams in an organization enhance the information flow especially so when the members meet each other face-to-face (which is the richest communication channel (Robbins, 2001) rather than through other channels which are less effective. In fact experts in the field of leadership advice that priority be given for face-to-face communication instead of the current "miss-use" of emails or other electronic channels (Sharma, 2010). This was echoed in the article by Rodney and Larry (2005) entitled "Effective internal communication starts at the top".

The shop-floor employees would thus need to have good communication to ensure it works as a team. Similarly in another research Bhupathiraju (2008), concluded that self-directed work teams are crucial towards the success of lean implementation. In fact it was stated in his work that teams are the backbone of implementing lean at any production facility. One good routine among teams in a lean manufacturing environment is the so-called daily meeting of the group members in a work cell. This often takes place prior to a shift change and it allows for crucial information flow from one person to the other. Any doubts can be clarified on the spot during that gathering.

Without teams the implementation would likely be hindered as it lacked the ability for the workers to be involved in the changes. It is safe to say that since the production workers are the individuals directly involved in the operation, empowering them to

develop the systems would go a long way to ensure success of the implementation. Teams in fact were identified as the solution for achieving the objectives of simultaneous increase in productivity and morale.

As would have been for any large Multi-National Corporation (MNC), emphasis on team (teamwork) had been an important aspect, and even more so today. An organization that achieves success can always link it to great teamwork (Robbins, 2001) and great leaders such as level 5 leaders who are described by Collins (2001) in the famous book "Good to Great". However in order for the great leader to garner the team towards his vision and mission, communication is of utmost importance.

Among many Japanese firms the employee suggestion system (which can be either by individuals or in groups called Quality Circles) is an important integral part of the company. The suggestion system allows for bottom up communication, which in essence allows shop floor members to provide their input to management. In this way the Japanese firms have successfully improved through the years as it practice Kaizen (Japanese word meaning continuous improvement), of which the teams could actively participate through the suggestion system set up. This is an important communication tool particularly for the non-management staffs (direct staffs such as operators and technicians who work at the shop floor level). Kaizen involves everyone, including both managers and workers. It is one of the postwar "economic miracles" for Japan (Imai, 1986). Through having such a mechanism in place the teams would be encouraged to brainstorm on issues and make suggestions that are fool proof. "Poka-Yoke", a Japanese word meaning mistake proofing is a practice that stresses the need to take corrective actions that are able to totally eliminate the problem. It is characterized by built-in methods within the system that prevent a particular problem or defect from occurring

(Nicholas, 1998). A good example would be the use of different connectors to avoid plugging into the wrong source.

In fact one of the important strategies advocated is the managing of creativity and innovation. This involves the process of taking creative ideas and turning them into new products, services, methods etc. (Hashim, 2005). Towards this end it is so important that the organization have a system to capture all its "know-how" and communicate them. In this way there would be no re-inventing of the wheels (Ahmed, 2009). It was found that the more new ideas an organization can generate, the more likely it will be to adjust successfully to its environment (Duhe, 2008). Towards this end having teams actively bringing about positive change through an effective suggestion scheme is vital.

When implementing lean manufacturing the organization would do well not only have teams working to eliminate waste but to inculcate valuable practices. Among them, Gemba Kaizen stands out prominently. Kaizen Events are basically continuous improvements, which are in small increments (Womack *et al.*, 1990). This is in contrast to innovation, which is in big increments. Gemba is a Japanese word meaning "real place", which today means "workplace" or "shop-floor" (Imai, 2001). When Gemba Kaizen is used, it refers to continuous improvement activities in the workplace. It involves going to the site and see for oneself what is actually happening (instead of imagining from the office). In this way the objective in Gemba Kaizen is to effectively (and practically) eliminate waste or non-value added job.

Much in line with the elimination of non-value added jobs is the practice of Value Stream Mapping (VSM) which the team could use. This exercise looks at the flow of the whole process and identifies what are the steps that add value and what that does not

(Rother & Shook, 1999). Based on the practice one can calculate the percentage of value added activity (which is useful as it allows for improvements to be tabulated in a way that can be easily understood). Lathin and Mitchell (2001) recommended the exercise of a value stream map to identify waste within the processes of the organization. This is also much in line with what Womack and Jones (1996) advocate. By continually mapping and identifying what really is value added and what is not (and eliminating it), the organization will grow from strength to strength.

With teams the organization could gain much by using techniques such as Single Exchange of Die (SMED) or Quick Changeovers for short (Shingo, 1985). It is characterized by the method to reduce the time taken to change a machine setting or to prepare an area to begin processing a new product. By having teams to work on it the suggestions generated are more likely to be practical and effective. Other areas where teams can have a strong impact in organizations are in ways to Reduced Cycle Time, which is the practice of reducing the time it takes to produce a product from the initial process to the finished good. The main aim is to analyze the process and make improvement towards its processing so that the time taken to transform it from raw material to finished goods is reduced. Fundamentally this would require identification of waste and thus making the process leaner.

The strength of teams essentially depends on the people who made up the team. In actual practice the effectiveness would be contingent upon how well versed they are on their job as well as the understanding of the philosophy the organization adopt. It is so important that the organization allocate sufficient resources to educating and training its personnel to increase the success rate of teams. A study on how well teams affect the

organization with respect to its internal supply chain would shed light on what kind of teams are effective and what are not.

Teams need not be confined to only those from a similar function. Infact cross-functional teams allow personnel to work with members of other departments while retaining their job content. Cross-functional teams are formed to address issues that require effort from more than one area of expertise. The teams can be organized around product lines, customer/market segments, and/or supplier characteristics (Robbins, 2001).

2.4.3 .5 **Lean Organizational Structure**

It is said that the trends in most developed economies are towards the devolution of decision making which often time would result in flattening of organizational structures (Patrickson, 1994). Organizational structure varies immensely. Some large companies have as many as twelve to eighteen levels of management between the board of directors and the employees producing the goods (Worley, 2004). The impact of having so many levels affect communication as it easily gets distorted thus affecting the effectiveness of the supply chain.

In a lean implementation, organizational structure in line with this view is practiced. With the flattening of the organizational structures, communication networks are likely to improve and will lead to building of employee empowerment (Heizer & Render, 2001). There would often be the need to enlarge the employee's jobs (job enlargement) so that the added responsibility and authority is shifted to the lowest possible level in the organization. By enlarging the job vertically the number of people

involved in the work stream reduces and indirectly reduces issues related to communication.

As an organization becomes larger, it is common to see an increase in the number of management levels between senior management and line employees. With the addition of more levels to its hierarchy, positions may be purposely created for job or activities that add little value to the customer (Barker & Cheney, 1994). When this happens, an organization may experience difficulty encouraging open communication. To overcome this lean manufacturing implementers would consider how it could re-structure its staff so as to achieve a more streamlined (flatter) organizational structure. With such a move the communication flow would be faster, shorter and more precise (Alavi, 2003). Studies have shown that such flat organizational structure enhance not only the communication and coordination within the organization but it also encourage creativity and innovation (Russell & Hoag, 2004). Nevertheless this seems to contradict the finding by Williams (1994), who argued that the conventional organizational structure is more efficient in adoption of technologies especially in overcoming resistance by lower level managers (senior managers using their authority can overrule decisions in adopting certain technologies).

Part of the stress in lean manufacturing is on "lean staffing" which seems to be adopted more and more in the US manufacturing companies (Glosser & Golden, 2004). With a leaner work force that is multi-skilled, it allows for more vertical integration (such as having one worker operating two different kinds of machines or processes compared to the conventional specialized operation). The end result of having a leaner work force in this manner would reduce the problems of communication especially since the number of people involved would be reduced.

Having said that the lesser number of personnel involved would result in better communication, there is always the limit to how low a headcount an organization can reach before it becomes counterproductive. As in most kind of implementations there is definitely a need for resources to be channeled. Lean manufacturing is no exception in this respect. A research among United Kingdom manufacturing small and medium enterprises (SME) found that the implementation of six-sigma which is related to lean manufacturing, was not successfully carried out in many of these sites. The reason for the shortfall was attributed to the lack of resources allocated (Anthony *et al.*, 2005). It is thus important that for the lean implementation to be successful, sufficient resource (in time, budget etc) need to be given. However apart from the resources the quality of the resource need to be considered (thus the importance of a good training programmed).

In a study done not too long ago in Hong Kong, the researcher managed to demonstrate how decentralized decision-making affect the information acquisition level (Li, 2008). This talks of the effect of the organization structure, which has an influence on how information flows in that firm. However the ability of the organization to decentralize its decision-making would need to take into consideration factors such as seriousness of an error if it happens, ability of the personnel concerned etc.

It cannot be denied that the organization structure alone would have little impact on the lean implementation if the leaders in the organization were not of the desired caliber. Among the critical factors for lean implementation, leadership stands up as one of the major ones. In a lean organization the leader would not only possess the necessary skills in communication but also by virtue of the organizational structure it

will enhance the communication (example through having less hierarchical structure) (Achanga, Shehab, Roy & Nelder, 2006).

One of the important principles in lean is to eliminate waste. In order to do so there is this stress to build a culture of stopping to fix problems so as to get the quality right the first time (Liker, 2004). Though in principle this can be understood however in practice it was found that this principle couldn't be so blindly adhered to. This was found to be the case in the research on lean manufacturing in temperature dependant processes with interruptions. In fact by stopping the process when a problem arises more quality problems are likely when production restarts. Such cases are not uncommon and calls for deep study to ensure that the principles be applied with an oversight of the total process (Lee & Allwood, 2003). Towards this end the researcher concluded that leaders play a most crucial part to ensure that the principles are followed intelligently by gathering inputs from the staffs who are involved in the operation.

Hoshin Kanri (envisioned from the Bridgestone Tire Company in Japan) is a Japanese term meaning "policy deployment" (Burnes, 2000). It starts with a top level objective which is then cascaded down to every level of the organization. One of the good points about Hoshin Kanri is its ability to communicate top level goals into quantitative and achievable actions (Liker, 2004). In a study on the application of hoshin kanri to improve productivity at a semiconductor manufacturing company (located in the Hsinchu Science-based Industrial Park, Taiwan), it was found that the case company managed to improve the productivity by 6% over a two year period (Yang & Su, 2007). This Japanese practice is among the many that is being advocated in the TPS as it brings about effective information flow from top management.

For an organization seeking to stimulate employee's ideas (innovation), it was found that leadership behaviors play an important part as it communicates to the staff what the organization seeks. Leaders influence employees' innovative behavior both through their deliberate actions (communication) and inactions at times, aiming to stimulate idea generation and application (Jong, Hartog & Den, 2007). Knowing the function of communication as such, it is important for an organization to place the right caliber leaders at appropriate positions so as to harness the best from the employees. The end result for so doing would be improved trust among the working members, overcoming fear of conflict, heightened commitment, accountability and focus on bottom line (Lencioni, 2002). In this way the supply chain (particularly in term of the information flow) can be strengthened. To get a clearer understanding of how organizational structure affect the internal supply chain it is thus necessary to obtain inputs from the personnel involved via survey or other means.

2.4.4 Challenges in Implementing Lean Practices

The road to a lean enterprise is one that would be worth it but will not be an easy one. Making major changes to business culture and processes is risky and much resistance can be expected, as most people would not want to change. However, equipping the organization with the proper knowledge, training and tools of lean manufacturing will greatly increase the probability of success.

Undeniably, for lean implementation to be successful there is a need for effective communication. It would be disastrous if there were a lack of understanding on the part of the employees that management's decisions and recommendations are made for the

good of all within the organization. This could lead to not only poor implementation but conflicts as well (Salamon, 2000). An organization with good internal communications builds trust and commitment and it has a positive benefit for all its stakeholders. Indeed employees who are well informed is a more credible representative of the organization than corporate communications efforts (Mishra, 2007).

The economic environment of manufacturing enterprises has changed drastically. Low costs and high quality are already taken for granted, and increasing attention is now being paid to the element of time. Faster product development and shorter lead times in procurement, production and distribution are the critical competitive factors of today (Smeds, 1994) .

In the quest to transform an organization towards a lean enterprise, there is a need to place a great deal of importance on issues regarding the manufacturing infrastructure such as workforce development and training, managerial leadership and commitment, team-based work organization, and the use of small groups or teams to solve problems and develop new production methods (Boyer, 1996).

As mentioned, the practices in Lean implementation take many forms such as visual management, organizational structure, teams and 5S. The outcome of these should be measured to ascertain its performance (Karlsson & Ahlstrom, 1996).

Some of the effects of lean implementation can be measured directly such as Turn-Around-Time Reduction (TAT), Set Up Time Reduction and Work-in-Progress (WIP) Reduction, while others such as layout change are measured indirectly through ways such as reduction in walking distance. Effect of 5S are measured through ways such as audits.

As in any management implementation, there is a need to measure the performance so as to enable the organization to evaluate the effort put in. In this way the organization can decide from the measurement whether to continue with the initiative, abolish it, modify it or act in whatever way it deem fit.

One of the challenges faced in lean manufacturing implementation relates to financial resources. This requires commitment from top management as the allocation of budget would require approval from the top level. Activities such as layout change are expensive and as such in-depth study would need to be carried out on a case by case basis to justify the change.

2.5 Theoretical Underpinning

2.5.1 Contingency Theory

Contingency theory states that there is no best way to run an organization or to lead a company or to make decisions (Fiedler, 1964). Instead, the best action is contingent (dependent) upon the internal and external situation or to phrase another way, the basic premise of contingency theory is that organizational design are contingent on environmental condition (Erik, 2010). To achieve high performance the organization would thus need to establish a "fit" between its internal and external environment where optimization of its operation can be realized (Donaldson, 2001, Lawrence and Lorsch, 1967). This thinking concurs with what Burns and Stalker (1961) argued long time ago that different kinds of management systems are suitable for different kinds of

environment. In more recent research it states that the supply chain performance is contingent on factors such as technological uncertainty etc (Fynes, De Burca & Marshall, 2004; Liao & Tu, 2008).

A change in the environment creates misalignment to occur between the environment and the organization. In response the organization makes adaptive changes so as to align (Demers, 2007). When organizations adopt a strategy it would result in changes towards its structure. This was put forth by Chandler (1962) who says that structures follow strategy. He explains that the structure is the way organizations are put together so that the strategy adopted can be administered (with hierarchies and lines of authority). Mintzberg (1981) elaborate this by saying that different strategies employed creates different administrative needs.

By applying and being aware of this theory, managers will recognize that the successful application of a strategy or technique in one situation does not imply success in another. Rather they will be able to examine each situation in terms of how it is affected by the environment (contextual, organizational and human dimensions) and derive possible solutions to a problem from numerous options.

2.5.2 Theory of Constraint

In essence the theory states that for any manageable system, it is limited in achieving more of its goal by at least one constraint. It seeks to identify the constraint and make improvement on it (Goldratt, 1990). Indeed it is an endless pursuit of perfection. He states that a business, like any system, operates with constraints. A

constraint is defined as anything that limits the performance of a business relative to its goal. In order to improve some steps need to be taken such as identifying the primary constraints, deciding how to exploit constraints, channeling all the needed resources to exploit the constraints, deciding whether it is necessary to elevate the constraints etc (Umble, Umble & Murakami, 2006). The stress is on adding value to the system.

When implementing lean practices the process of identifying the bottleneck or area of constraint is very important. It is only by accurately identifying and working towards addressing the bottleneck that will result in an improved overall performance. As the bottleneck is improved the next constraint will appear and so the continuous improvement process is activated.

The theory of constraints describes lean practices well. Practitioners who subscribe to the theory would seek opportunity to improve their organization by limiting their focus on very few issues, which are the seen constraints to ongoing progress of the business. The elimination of any or all waste is what the practitioners strive for when it goes for lean practices. By focusing the limited resource at the constraint areas organizations would be able to increase their overall productivity. This is in contrast to other conventional strategy where improvements are made at random areas which in the first place may not be a constraint point.

2.6 Case Study Site

2.6.1 History

Renesas Semiconductor (Malaysia) Sdn Bhd is a world-renowned semiconductor manufacturer and one of the pioneers in Penang and Kedah. The name **Renesas** is derived from "**Ren**aissance **S**emiconductor for **A**dvanced **S**olutions". As the name suggest the nature of business is to manufacture and sell semiconductors. The company is a foreign owned subsidiary with its head-quarter in Japan.

Established in 1972 as Hitachi Semiconductor (Malaysia) Sdn Bhd in a Free Trade Zone area, it merged with Mitsubishi Semiconductor in the year 2003. With the merger, a new company name as well as a totally new brand name was established. Since its merger the company has put in a concerted effort in promoting its new brand name worldwide. The company is among the top semiconductors producer in the world. It joins the many players in this large industry.

Renesas Semiconductor (Malaysia) Sdn Bhd is a holdings company with 90% share held by Renesas Technology Corporation and the other 10% Amanah Raya Berhad. The factory located in Penang sits on a 13.5 acres land near to the airport. In fact it is just about 10 minutes drive away from the airport and this provides it with a strategic logistic position. The company has an authorized capital of RM 100,000,000 and a paid-up capital of RM 84,000,000. The population of this organization varies depending on the business situation, but in general it has more than 1000 employees. These consist mostly of operators, technicians, engineers followed by management staffs etc.

Taking advantage of the favorable exchange rate, Renesas Semiconductor (Malaysia) Sdn Bhd has thus far able to show quite impressive results through the many years since its inception. In fact the head office in Japan is keen to increase its overseas contribution by venturing out. This is to take advantage of factors such as tax incentives, free trade zone, qualified human resource etc apart from having favorable exchange rate. However the organization is also fully aware that it cannot rely on the exchange rate factor to be competitive as this can and does change. The key point as manufactures is to ensure that the fundamentals are strong. Towards this end it strives to be as efficient as possible, via activities such as Total Preventive Maintenance (TPM), Zero Defects (ZD), Small Group Activities (SGA) etc.

As for the range of products it produces, Renesas Semiconductor (Malaysia) Sdn Bhd manufacture semiconductors Small Signal Transistors, Power Transistors, Linear Integrated Circuits, Glass and Resin Diodes and Digital Integrated Circuits.

2.6.2 Organizational Structure

Being a Multi-National Corporation (MNC) many expatriates were posted here to work (about 50 expatriates will serve here at any one time). It is thus a company that is influenced much by Japanese culture. The top post such as the Managing Director and many advisors are from Japan. In the last 10 years however there has been a shift towards allowing more and more locals to hold high positions such as to be appointed as General Managers and Directors. With such a mix, Renesas Semiconductor (Malaysia) Sdn Bhd has evolved through these years to its own unique culture.

It's a normal practice by the company to have a new Managing Director (MD) every 3~5 years cycle. With this cycle also comes the introduction of various changes such as introduction of Lean Manufacturing, Total Productive Management (TPM), Quality Control circle (QCC) etc which are associated with the Chief Executive Officer (CEO). The organizational structure consists of the MD being overall in-charge, followed by a group of directors which consist both of local members as well as Japanese. This is important as communication with Japan need to be done seamlessly and as such to do so the Japanese directors need to be familiar with the actual happenings so as to provide value added support. The main purpose of the company is to manufacture. As such the organization is structured into a few production groups. Non-manufacturing departments such as Accounts, Human Resource, Purchasing, Information and Technology etc are classified as supporting departments which are essential to ensure smooth running of the whole company.

In order to ensure the internal supply chain is well connected, frequent meetings of departments heads are organized in order to share information and keep each other abreast on the happenings in the company. An example of this is the weekly Senior Managers Meeting which is chaired by the MD. In this meeting every department in the organization is being represented and many important clarification as well as decisions are made. It also provides an avenue for information flow to the external supply chain via related representative present.

2.6.3 Manufacturing Information

Sales for Renesas Semiconductor (Malaysia) Sdn Bhd averages about RM 90,000,000 per month in the year 2008 and 2009. In 2010 it averages RM 100,000,000. A big portion of all that it produces is exported, mainly back to Japan itself. There is however emphasis on growing the direct sales market (selling direct to customers apart from Japan) segment of the business where the current sales only register less than 10% of total sales.

One of the main reasons why this segment could not grow to its targeted 30% plan was due to the steep competition particularly from low cost producers in countries like China, Taiwan and South Korea. Towards this end the CEO has always been challenging the staffs to at least be on par with their competitors in China. Among the many pressing issues when benchmarked with its competitors are the issues like long turn-around-time (TAT), poor quality and high cost. These are among the issues that the organization hopes to address by improving its supply chain through engaging appropriate strategy such as lean manufacturing.

World trend for semiconductor goes through cycles and only those, which have strong foundations stays. Renesas Semiconductor (Malaysia) Sdn Bhd is among the top 10 manufacturers of semiconductors in the world. In fact in 2009 it was ranked 9th biggest by virtue of revenue. A year later (2010) it climbed to the 5th position, making it the one of the most significant Japanese company in the world. This can be seen in the Table 2.2 below,

Table 2.2

Worldwide Revenue Ranking for the Top-25 Semiconductor Suppliers

Final Worldwide Revenue Ranking for the Top-25 Semiconductor Suppliers in 2010

(Ranking by Revenue, Millions of U.S. Dollars)

2009 Rank	2010 Rank	Company Name	2009 Revenue	2010 Revenue	Percent Change	Percent of Total	Cumulative Percent
1	1	Intel	$32,187	$40,394	25.5%	13.3%	13.3%
2	2	Samsung Electronics	$17,488	$27,234	55.7%	9.2%	22.4%
3	3	Toshiba	$10,213	$13,010	27.4%	4.3%	26.7%
4	4	Texas Instruments	$9,671	$12,994	34.4%	4.3%	31.0%
9	5	Renesas Electronics Corporation	$5,152	$11,592	125.0%	3.8%	34.9%
7	6	Hynix	$6,246	$10,280	64.6%	3.4%	38.3%
5	7	STMicroelectronics	$8,510	$10,348	21.6%	3.4%	41.7%
12	8	Micron Technology	$4,262	$8,878	108.3%	2.9%	44.6%
8	9	Qualcomm	$5,405	$7,204	12.4%	2.4%	47.0%
14	10	Broadcom	$4,278	$6,882	60.2%	2.2%	49.2%
15	11	Elpida Memory	$2,648	$6,446	83.3%	2.1%	51.3%
6	12	Advanced Micro Devices (AMD)	$5,207	$6,345	21.9%	2.1%	53.4%
11	13	Infineon Technologies	$4,466	$6,319	41.5%	2.1%	55.5%
10	14	Sony	$4,488	$5,224	16.9%	1.7%	57.2%
16	15	Panasonic Corporation	$3,242	$4,946	52.5%	1.6%	58.8%
17	16	Freescale Semiconductor	$3,402	$4,357	28.1%	1.4%	60.2%
18	17	NXP	$3,240	$4,028	24.3%	1.3%	61.6%
22	18	Marvell Technology Group	$2,572	$3,622	41.2%	1.2%	62.8%
19	19	MediaTek	$2,551	$2,553	0.1%	1.2%	64.0%
20	20	nVidia	$2,328	$3,196	12.1%	1.1%	65.0%
21	21	ROHM Semiconductor	$2,588	$3,118	20.5%	1.0%	66.0%
23	22	Fujitsu Semiconductor Limited	$2,574	$3,090	20.0%	1.0%	67.0%
24	23	Analog Devices	$2,091	$2,882	38.9%	0.9%	68.0%
30	24	Maxim Integrated Products	$1,667	$2,367	42.0%	0.8%	68.8%
29	25	Xilinx	$1,696	$2,311	36.0%	0.8%	69.5%
		All Others	$73,112	$92,887	18.6%	30.5%	
		Total Semiconductor	**$230,194**	**$304,075**	**32.1%**	**100.0%**	

Source: IHS Quest, April 2011

As a business strategy, the company has established a strong SCM. It has successfully sailed through many difficult periods but with the current challenges it strives to strengthen its supply chain further. Upon reflection it can be seen that most of the effort in SCM thus far has been concentrated on the external aspect such as dealings with suppliers of raw material. The supply chain established with its many vendors has in a sense matured and come to a point of saturation. The quest to "squeeze" what the vendor can offer seems to have ended. At times due to over "squeezing" negative impacts such as poorer quality control creates additional problems, which are often time costly.

Following the footsteps of many successful organizations which have improved their supply chain through strategies such as implementing lean manufacturing (Ahls, 2001; Alavi, 2003), the CEO decided to follow suit.

2.6.4 Internal Supply Chain Scenario

For Renesas Semiconductor (M) Sdn Bhd, the relationship with suppliers (or external chain), have matured through the years. This can be seen by the close rapport in their relationship. On a yearly basis the parties concerned will meet to consider how they can improve the existing supply chain. With this mechanism in place it has help the parties concerned in understanding each other's situation as well as make mutual effort to improve the supply chain. Issues of logistics, cost, quality etc were being addressed.

However, internally in the organization this cannot be said to be true. An obvious weakness can be observed in that each production line would stock as much material as they can (which can last for many days) without consideration that they are actually holding up the cost. Reason for doing so were most likely due to past experiences or fear that they may run out of material for smooth production or to create safety buffer stock just in case of abnormalities such as machine breakdown. As the product is being processed from one point to another this phenomenon of keeping high inventory is common. In fact as mentioned by some people the organization seems to be practicing "Just-in-case" instead of "Just-in-time"!. This observation of high inventory is based on the weekly inventory report published internally in the organization of which an example is shown in appendix 2.

Apart from the issues of inventory, there is also the issue of turn-around-time (TAT). This refers to the time it takes to transform from raw material to finished goods. A measure used in the industry to judge the health of an organization is to compare their turn-around-time, with those having a short turn-around-time being more efficient. In general compared to other Renesas subsidiaries, this organization seems to be lagging behind. With a longer turn-around-time time the supply chain becomes more inefficient apart from the fact that delivery time to customers becomes unsatisfactory, thus affecting the customer satisfaction. Quite often there will be the urgent request to expedite certain products due to customer line stopping due to not receiving the product on schedule.

Renesas Semiconductor (Malaysia) Sdn Bhd boast of a strong ICT implementation. Companywide there is a system which basically consists of the ERP system while at the operations level Manufacturing Execution System (MES) plays a very important part to move the operation. As a whole the systems have been evolving through the years in tempo with the ever changing demands (which requires frequent review of how the company ought to conduct its business). For instance when the company adopted lean practices, it changes the way products are moved virtually. In the past it was a push system whereby products are produced and pushed down the internal supply chain. This resulted in unbalanced product mix which often could not meet the customer's need due to production line producing not in the order needed by customers but rather in the order to maximize productivity. When lean was practiced, the system was changed to a pull system. In order to make this change, the MES was modeled (re-programmed) so as to pull the correct combination of products through the internal supply chain. It was a case where the production line will be instructed through the system on what to produce at any given time so that ultimately the customer's request was being given priority. Not

only is the product movement monitored by the system but through intelligent linking many triggering points exist in which the supply chain is kept in good stead. This can be seen by how raw materials are procured through the system when its determined stock level drops below the order point. Even for consumptive jigs such as capillaries and collets which are vital components for the manufacturing process the use of the ERP and MES systems to track its usage as well as triggering orders are widely used (which need to be planned well as the lead time to purchasing them can be as long as three months).

2.6.5 Lean Initiative Background

Knowing the need to differentiate itself from its competitors, Renesas Semiconductor (Malaysia) Sdn Bhd introduced Lean Manufacturing in the year 2005. The aim was to complement existing strengths that the organization has built up. Among the strength is the fact that it has been successful in harnessing the good effect of SCM for many years. In a sense the organization has been successful in being competitive through many efforts of which SCM is a major contributor. However despite these achievements, there is this difficulty still faced in the light of new developments. As is common knowledge, the emergence of competitors from emerging economies such as in China, Vietnam, Korea etc have indeed affected the business of Renesas Semiconductor (Malaysia) Sdn Bhd. This scenario is being echoed by many researches who talks about the need to be alert on the threat faced locally and across borders (Oliver & Webber, 1982; Lambert, Cooper & Pagh, 1998).

Looking at its other subsidiaries Renesas Semiconductor (Malaysia) Sdn Bhd found that some of the factories situated in Japan itself have somehow made breakthroughs

despite the fact that they are disadvantaged due to their domestic scenario such as high wages and also the non favorable currency exchange rate. It was found that these successful sites have introduced lean manufacturing to their operation. The lean implementation was found to focus on strengthening the value chain within the organization.

In Lean Manufacturing implementation, effort is being made to reduce waste or non-value added activities in the supply chain. It is important therefore that the supply chain management practiced should ensure the smooth flow of material and information not only externally but internally too. The strategy to utilize lean practices in improving the company is being encouraged by cases of successful implementations where benefit to the organizations was evident (Singh *et al.*, 2010). These success stories are not only confined to Japan but also elsewhere like in China, India etc (Taj, 2008; Taj & Moroson, 2011; Boyle & Rathje, 2009)

After having implemented lean manufacturing (based on Toyota Production System) since 2005 (the company's history started from 1973), the management of Renesas Semiconductor (Malaysia) Sdn Bhd starts to reflect on its progress. This act of reflecting on the project itself is part of Toyota Production System (TPS), and it is called "Hansei" (Liker, 2004) in Japanese. Many questions arose upon reflection. These are honest questions in assessing whether the decision to implement Lean Manufacturing was worth the effort or otherwise especially on how it has affected the supply chain. Among the decisions that the management intend to make pertains to expanding its lean implementation to its other section which has not been the focus of lean effort thus far (The factory can be divided into two namely Section 1 and Section 2

and though the implementation was to be across the board the focus has been mainly in Section 1 thus far).

Production cost has always being an issue for all organizations (Soni & Kodali, 2010). However for Renesas Semiconductor (Malaysia) Sdn Bhd, the situation has become more critical with the emergence of many new competitors in this fast changing world (Christopher, Peck & Towill, 2006). With low labor cost and many incentives provided by the individual government, competitors from countries such as China, Vietnam, Thailand etc are becoming a real threat. The rate of cost reduction in the organization does not seem to be able to cope with the competitor's rate of cost reduction seen through their pricing strategy. Nevertheless the implementation of lean which promotes elimination of waste does have some impact in regard to reducing loss. Tangible results can be seen in areas such as reduction of product being thrown away due to over-processing, less labor requirement as a result of work simplification where more value add jobs are being performed against earlier high non value add jobs, less holding cost due to reduction in inventory etc (Liker, 2004; Liker & Franz, 2011).

To add on to the issues faced, changes in the product demand are putting much pressure to the already stressed workforce. This is because the trend in production is now towards small batches due to increase in customized products (Arnheiter & Maleyeff, 2005; Agus & Hajinoor, 2012). For the organization it needs to be able to respond fast to the changing request. Fast changeover time is of much importance in such situation. In such a scenario the supply change management established becomes stretched as it need to ensure the continuous flow of different material types arriving at the right time and in the right quantity. One prominent activity in line with lean practices carried out in the organization was the promotion of Quick Change-over Time

or Single Minute Exchange of Die (SMED) activities. This activity does affect the supply chain flexibility as it allows for more conversions to be carried out with minimal loss of capacity, thus meeting the diverse customer's request.

As part of lean manufacturing implementation, the company embarks on making layout changes in line with TPS philosophy. Much financial resource was channeled towards arranging the processes in the production floor into cellular form (meaning grouping a few processes into one production area). In this way the flow of material as well as information could be enhanced and thus improving the internal supply chain. Some outcome that emerge from the layout changes in line with lean practices are that it promotes internal supply chain integration. As an example some processes were able to be integrated together as one process instead of multiple processes, thus improving the efficiency as well as the lead time. These changes could not materialize without the physical relocation and relay-out activities.

5S was not only preached but practiced. Apart from educating on what 5S really is, the top management can be seen involved in doing weekly audits to ensure compliance to the rules set by the organization. By doing so the company not only looks orderly but it allows for reduction of waste such as time to find a tool (now tools are placed in specific locations that are easily accessible). With a place for all things and all things in its place, the obstruction to movement both of human and products is minimized. Material flow can be seen to have improved as there is now fixed location for a fixed amount of inventory (material, products etc). It can be said that this activity is an important foundation towards ensuring a successful lean implementation as also can be seen in a study of a Brazilian company producing cups for packaging food products.

The lean implementation utilized the 5S technique to achieve a dramatic improvement in the internal process (Pranckevicius, Deisell & Howard, 2008).

Visual Management was implemented when lean was introduced in the organization. Effort to make things "visible" can be seen examples such as clear indications for almost any and everything. By practicing concepts such as having an area indicated for a particular raw material the process owner would also be required to indicate the maximum stock allowed there. As such anyone who walks the process could see if any abnormal stock situations arise. Visual management in the form of having big display boards showing machine status, inventory status, human resource status, production status, quality status etc have been implemented, much in line with what is advocated by Mann (2005). At the point of this research the company has also embark on digital display boards which provides real time information for purpose of tracking the key performance indicators (KPI). One recent example from the digital display is the weekly update on customer complaints. This is part of the effort to towards customer responsiveness whereby it is expected that after having known the customer complaints or request the related members would be able to respond accordingly.

The management of this organization has long understood and acknowledged that every level of the workforce contributes to the productivity of the company. With that in mind, the company has evolved over the years its own unique and highly successful teams such as the quality control circle. These teams are self-directed teams and many success stories can be seen in the organization. With these teams the organization has effectively empowered the employees from the shop-floor level to bring out their own ideas and suggestions of how innovation and best practices can increase the productivity

of their respective sections. In the organization teams can consist of similar process or job function members or even cross-functional. Results and activities of these teams are also displayed prominently for all to see. There have been claims that barriers in information flow have been reduced through these teams.

Organizational structure in the organization aims to be as flat as possible so that the information flow can be effective. In order to balance up the need of promotion and yet having as flat an organization as possible, the organization implemented a ranking system which allows for a rank up without having an organization change. In this way the affected member enjoys the benefit of a "promotion" while still retaining the current job function. Apart from the motivation aspect there is the issue of information flow which the flat organizational structure hopes to address.

These activities are much in line with lean practices and have been carried out in many companies around the world. In a recent study of 107 companies across Europe these practices have been observed though impact on each organization varies (Chiarini, 2011).

2.7 Research Framework

Based on the relationship between the various variables in this research, the framework as in Figure 2.1 is put forward.

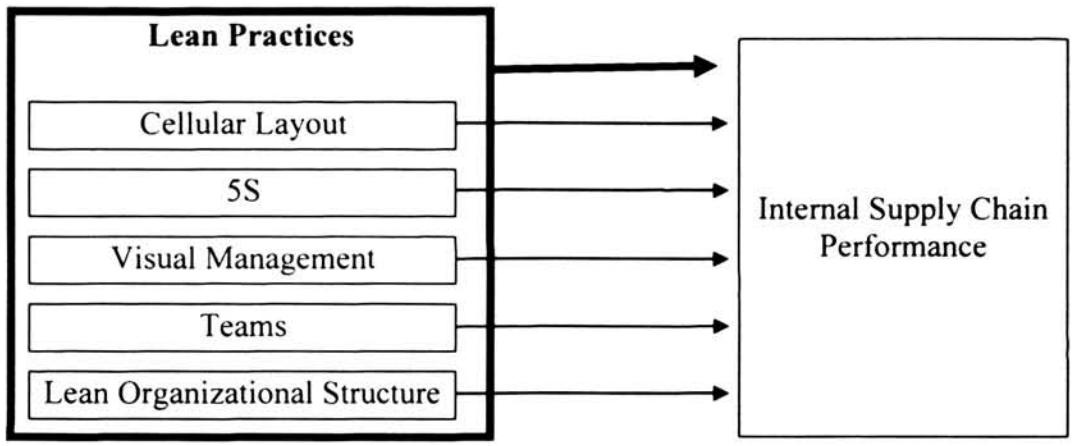

Figure 2.1
Theoretical Framework

The dependent variable refers to the internal supply chain performance while the independent variables refer to the lean practices (cellular layout, 5S, visual management, teams, lean organizational structure and lean practices as a whole).

2.8 Summary

This chapter presented an overview on supply chain and narrowed down to the theme of internal supply chain performance. The background of lean manufacturing covering the philosophy, how it came about and also the theoretical underpinning was documented. Specifically the common lean practices were elaborated on. After providing the information about case study site, the research framework was drawn followed by the 6 hypothesis to be tested. In the next chapter, the focus shifts to a

detailed account of the research design, research methodology, data analysis technique and will touch on the pilot test result.

CHAPTER THREE: METHODOLOGY

This chapter will in essence describe the methods and procedures used in carrying out this study. It covers collecting and analyzing of data in relation to the research objective. It also set the site for the study, providing a rationale for its selection. The research instrument with its reliability and validity will be clarified. It should be noted at the outset that the methodology was to a certain extent an evolving one that took definite shape as the study progressed as ascribe to by many who have taken the same journey (Glatthorn,1998).

3.1 Research Design

Research design is a master plan specifying the methods and procedures for collecting and analyzing the needed information. It is the framework that spells out the action for the research project (Zikmund, 2003) of which the independent variable refers to the perception of the internal supply chain performance and the dependant variables to the various lean practices as mentioned in the research framework.

In evaluating the best research design to consider, it is wise to heed the views of researchers who argue that there is no one best designs for all situations. It was said that "There is never a single standard, correct method of carrying out a piece of research. Do not wait to start your research until you find out the proper approach, because there are many ways to tackle a problem – some good, some bad, but probably several good ways. There is no single perfect design". (Simon, 1969).

This research would be a quantitative one, wherein it will attempt to measure the perception of the population in a selected site. The population is grouped into two groups, namely one being those exposed to Lean Practices or in a Lean Implementation while the other consist of those who are not exposed. It will measure the perception of these two groups through a survey using self administered questionnaires which is adapted from Li (2002) and Qrunfleh (2011). The design of this research is one that is descriptive (which in a normal situation the subjects are measured once) and at the final analysis would attempt to establish associations between the targeted variables (Zikmund, 2003; Diebold, 2007). Being a descriptive study there is however a need to ensure sufficient samples so as to reduce issues relating to bias. The researcher took effort to ensure a good respond rate in this study through actions such as having email reminders, face to face interaction, joining in some group meetings where the purpose of the survey was explained etc (Zikmund, 2003; Saunders, Lewis & Thornhill, 2003; Hair, Black, Babin, Anderson, Tatham, 2006; Krejcie & Morgan, 1970).

In order to evaluate the appropriate method to adopt, consideration is given to the time frame of this project, cost of obtaining the data, the availability of the data etc. This research project is a single case study of which the research methodology relies on multiple sources of evidence so as to add to the breadth and depth of data collection. Such single case studies can be seen in numerous research such as the one carried out in Northeastern United States of America on the subject of how a manufacturing plant perform in its integrated industrial supply chain (Elmuti *et al.*, 2008). To assist in bringing forth richness of data together, triangulation would be carried out so as to contribute to the validity of the research (Yin, 2003). In the final compilation of the research findings, this approach will enable the combination of a variety of information sources, including documentation, interviews etc.

A cross-sectional survey was carried out to gather data at a single point in time, so as to answer the study's research questions. Survey is a common method and one that could easily be understood and accepted by the population in general. This is because most people have been exposed to a survey at one time or another (Zikmund, 2003). Furthermore a survey method was employed because this study strongly believes that survey research is best adapted to obtain personal and social facts, beliefs, and attitudes (Kerlinger, 1973).

As part of strategy to obtain good response, the layout of the questionnaire form is designed to be clear and not threatening (such as no necessity to inform name). At the front part of the questionnaire, clear explanation of the purpose is made (Saunders *et al.*, 2003). A font size of 12 is purposely used to ease those who may have difficulty reading. In forming the questionnaires (which is adapted from the works by Qrunfleh, (2010), Li (2002)), simple words and short statements are used so as avoid "threatening" any respondent (Saunders *et al.*, 2003). The final questionnaire as in Appendix 2 was refined a few times after having feedbacks. This format can be used as in a hardcopy or electronically. Since the respondents all have access to the e-mail, the electronic version is widely used. Some features in the design of the questionnaire which ultimately reduces the number of rejected responds are:

a. It will prompt an error message ("error!") when more than one tick is being made for each question (however this is applicable for those who responded via softcopy.
b. Chances of missing some questions are reduced as there will be a message in red letter (example "You have missed out 2 response(s). Please check

again") at the remarks area to inform number of questions not answered (this is programmed inside the worksheet).

c. Upon successfully completing the questionnaire, a message in blue color will be displayed ("THANK YOU FOR YOUR TIME. INFORMATIONS WILL BE KEPT PRIVATE AND CONFIDENTIAL"). In this way too the researcher is able to make a fast check on the responds just by looking at the remarks row.

Pertaining to the way the questions are arranged, it will be such that there is a flow for the respondents. The demographics questions are purposely placed at the end as it helps some people who may be feel threaten when asked such questions upfront. This method was employed by some researchers (Qrunfleh, 2011; Li, 2002).

A cover letter is enclosed together with the self administered questionnaire for each potential respondent. This short letter provides clarification on why this exercise is being carried out, explains what the respondent need to do and also assure them of confidentiality (Gay & Airasian, 2003).

3.2 Population and Respondents

3.2.1 Population

The population of this study is made up of indirect employees (in contrast to the direct employees who are doing the actual physical operation of the organization) of the case study site. They consist of the personnel in the managerial functions (directors, production managers, quality assurance managers, maintenance manager and planning

managers), engineering functions (process engineers, quality assurance engineers, maintenance engineers) and operational functions (production supervisors, quality assurance supervisors and maintenance supervisors). The size of this target population as at the point of this research stands at 341 with the breakdown as in Table 3.1.

Table 3.1
Population in Case Study Site

	Head count	%
Operation	96	28%
Engineering	202	59%
Management	43	13%
Total	**341**	**100%**

The main bulk of the population are those under the engineering function (59%) followed by those in operation (28%) and lastly those in the managerial function (13%).

3.2.2 Respondents

This study attempts to obtain the responds from the population instead of doing a sampling as the researcher has the ability and resource to collect data from the entire population (Saunders *et al.*, 2003). After having informed the various department heads of this research (through face to face explanation), the researcher managed to send out the questionnaire (appendix 1b) along with the cover letter (appendix 1a), to all the population as shown in Table 3.1 earlier (less by 23 who were selected for the pilot test). Though not all responded, the response has nevertheless being very encouraging. A total of 190 responses were received of which 4 were rejected for reasons such as incomplete answering and illogical entry (example – double tick). As such 186 (58% response rate) responses were accepted and used for analysis. In all the time frame taken

from the onset of questionnaire distribution till the acceptance of the responses took about 2 months. Details of the respondents are shown in Table 3.2.

Table 3.2
Respondents in the Case Study Site

	Head count	Questionnaire sent out	Accepted Responses	Response Rate
Operation	96	93	51	55%
Engineering	202	186	97	52%
Management	43	39	38	97%
Total	341	318	186	58%

On a random basis some respondents were asked to elaborate on their replies based on the survey and these comments were captured in appendix 9.

3.3 Data Collection and Instrument Used

The primary concern in this research is on the perception of the staffs working in the selected case site. In order to obtain this perception the instrument used is an adapted self-administered questionnaire which was dispatched to the said population. Due to the fact that almost every member in the population have access to e-mail, majority of the respondents gave their respond via e-mail. This option was made more desirable through the specially designed questionnaire format (though the questionnaire was adapted the format and arrangement was modified) as in appendix 2 where all the respondent need to do is to click appropriate boxes. After having done so the individuals will send the respond back via e-mail. This method is both economical as well as efficient. It also provides ample time as the respondents need not be hurried. However setback faced using this method was that some members unintentionally forgot as they

postpone responding and the email became "submerged" among their many mails. In order to improve the responds a few reminders were sent out. This helps.

Question of confidentiality was addressed through the cover letter to them. With all this in place the response rate has been quite satisfactory at 58%. The researcher compiles each and every reply into a database using Microsoft Excel before transposing it and pasting into the Statistical Packages for the Social Sciences (SPSS) version 17.0. This software is used for both the compiling and analyzing of data collected. The manner of using the SPSS software is being guided through the use of help books such as by Coakes, Steed and Ong (2010).

When the respondent clicks on to the questionnaire (soft-copy) it automatically captures a respond code which was predetermined. Example if the respondent clicks the respond for Strongly Agree the code "5" will be captured for that particular question. In this way the researcher was able to easily compile the responds by collecting all the codes generated (Gupta, 1999).

3.4 Method of measurement

Apart from the demographic factors, all other variables included in this study were measured using multiple items drawn from previous research. However phrasings of the items were modified to suit the sample and local setting.

In order to ensure consistency among variables and to avoid confusion among respondents, all the items were measured using the Likert-style rating scale (Saunders *et al.*, 2003). A scale of 1 to 5 was used to measure the degree of agreement or

disagreement pertaining to the specific questions asked. This scale consist of "1" being "Strongly Disagree", "2" being "Disagree", "3" being "Neutral", "4" being Agree and "5" being "Strongly Agree".

As for the demographic details, the process is made "user friendly" through simple check boxes in appendix 2.

3.5 Data Analysis Technique

All data were compiled and analyzed using Statistical Packages for the Social Sciences (SPSS) version 17.0. For all analysis discussed, a significance level of 0.05 was used. A p value less than 0.05 indicates the rejection of the null hypothesis and a p value more than 0.05 indicates acceptance of null hypothesis. Descriptive statistical analysis was carried out to determine group statistics for the sample which covers mean value, standard deviation and standard error of mean. As the study involves comparison of groups, independent t-test will be carried out for groups of two while comparison of groups more than two the analysis of variance (ANOVA) were used for inferential statistical analysis (Coakes *et al.*, 2010; Lay & Khoo, 2009)

Since such data analysis assumes the need to have a normal distribution (Coakes et al., 2010), it is appropriate to mention that the sampling distribution is normal since the sample size is more than 30, and the central limit theorem states that the sampling distribution should be normal when samples are big (Field, 2009). Nevertheless for this study the normality for the data compiled was shown graphically using the Normal Q-Q Plot (via use of SPSS) as shown in Figure 3.1 where it shows a normal distribution.

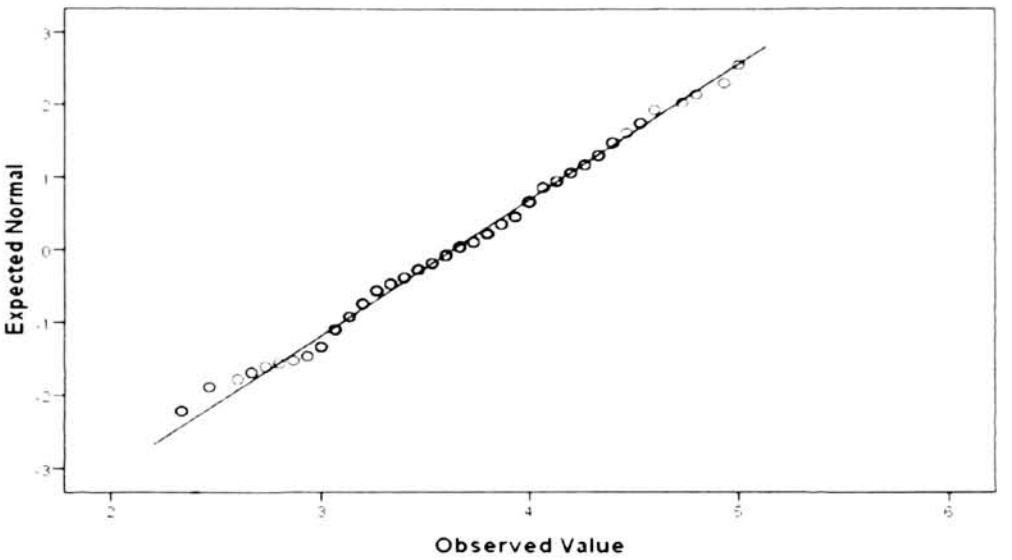

Figure 3.1
Normal Q-Q Plot of Mean of Internal Supply Chain Performance

Correlation analysis was used to examine the relationship among variables while comparisons of 2 groups were analyzed through independent t-test. As for cases where there are comparisons of more than 2 groups, ANOVA was used.

As for ease of understanding the analysis, various statistical tools were used such as pie charts, graphs, tables etc. Many of these were generated via the SPSS software used and through Microsoft Excel.

3.6 Pilot Study

Before embarking on a mass survey, the researcher conducted a pilot study for the self-administered questionnaire. This is to assess the understanding of the respondents pertaining to the questions asked in the survey. Apart from assessing the clarity of questions it also provides feedback on the appropriateness of the response categories,

adequacy of instructions, effectiveness of data capturing and also enable the editing of fields where deemed necessary. The pilot study also entails interviews so as to obtain feedbacks or recommendations through face-to-face encounter. From the pilot study result it also enable a mock-up of data output.

This pilot study was conducted in July 2012 involving 30 respondents from the case study site. From these only 23 responded (78%). These respondents were selected on a random basis and were also asked to indicate to the researcher problems faced while responding to the questionnaire. The responses such as difficulty in understanding certain statements were noted and refined in the final questionnaire. Based on feedbacks from these who responded, it takes about 25 minutes to fill up the questionnaire. A few respondents informed that they have problem with time since there is a need to focus and read through the questionnaires. These observations and feedbacks becomes important information for the researcher to address so that during the mass survey proper situation will be conducive. In view of the tight time factor to get respondents to go through the self-administered questionnaire, arrangements were made with department heads to allow the researcher to brief their subordinates during department weekly meetings. With clear explanation as well as the opportunity to question the researcher himself it would pave the way for a satisfactory respond rate during the mass survey. Some respondents during this pilot study fed back personally that the survey creates a "pressure" on them since the number of questions seems to be many. This was addressed by re-phrasing questions which are lengthy while at the same reassuring the respondents that the time taken would not be excessive.

Changes made to the instruments after the pilot study are,

i) The respond column was changed from having to circle the appropriate number (1 to 5) to using a check box method as this is more user friendly particularly for those using the electronic version

ii) Demographic details were shifted from beginning to the end portion as the respondents felt that they are more comfortable with such sequence.

iii) Some of the questions in the survey were shortened as the respondents informed that the elaborate statements are unnecessary. Examples of the questions that were shorten are

   a. "Handle difficult non standard orders (such as same type but different customer and the specification is different)" was shorten to "Handle difficult non standard orders"

   b. "Meet special customer specification (such as different material for different customers even though same type)" was shorten to "Meet special customer specification"

iv) The explanation of the scale (such as if choose "1" it refers to Strongly Disagree and so on) is displayed in every page instead of originally only shown at the front page. It allows for easy reference instead of having to flip back to check when unsure.

3.7 Reliability and Validity

Based on the pilot study response of the self-administered questionnaire, the researcher did a reliability analysis to verify whether it is acceptable. This exercise is an assessment of the degree of consistency (internal consistency) between multiple measurements of a variable (Hair *et al.*, 2006). Reliability analysis is done by obtaining the Cronbach's alpha coefficient (which refers to the degree to which items in set are

homogeneous). A value of 0.6 to 0.7 is considered as the lower limit of acceptability and a value of 0.7 to 0.8 would be desired of which certain variables may need to be excluded or reviewed if its Cronbach's alpha is not within this limit (Hair *et al.*, 2006; Coakes *et al.*, 2010).

Reliability statistic analysis for this research pilot study is summarized as in the Table 3.3 below.

Table 3.3
Reliability Test - Cronbach's Alpha

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.940	.941	60

Based on the the Cronbach's Alpha value of 0.94 the result of the analysis should be accepted (Hair *et al.*, 2006). A breakdown of the Cronbach's Alpha by each variable also displays a similarly acceptable value for all the variables as shown in Table 3.4.

Table 3.4
Reliability Test - Cronbach's Alpha (By Each Variable)

Variable Name	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items	Remarks
Cellular Layout	.725	.733	9	Accepted
5S	.889	.890	9	Accepted
Visual Management	.869	.874	9	Accepted
Teams	.862	.862	9	Accepted
Organizational Structure	.876	.880	9	Accepted
Lean Practices	.923	.924	45	Accepted
Internal Supply Chain Performance	.922	.923	15	Accepted

The instrument used in this research to measure the perception of internal supply chain performance is one that is adopted from previous studies (Li *et al.*, 2006; Li *et al.*, 2002; Qrunfleh, 2011). These instruments have been tested in previous studies and found to be valid.

Nevertheless an attempt was made by the researcher to obtain the expert opinion of some personnel who are familiar in this field of internal supply chain performance. Apart from getting their opinions on the wording of the questions the experts were asked to about the suitability of each item inside the questionnaire. To measure the suitability of the items they were requested to rate each and every questions using a 5-point Likert scale. The suitability of each items were rated using "1" being "Very Unsuitable", "2" being "Unsuitable", "3" being "Neither Suitable or Unsuitable", "4" being "Suitable" and "5" being "Very Suitable". Computation of the mean was carried out with results showing all of the means are greater than 3. In fact majority are greater than 4. It can be said that the content validity of the questionnaire or item is high based on the mean (Gay & Airasian, 2003). Table 3.5 shows the content validity by detailing the mean of each question.

Table 3.5

Content Validity (By Experts Opinion)

Question #	Expert Opinion 1	2	3	4	5	6	7	8	9	Mean
A-1	5	4	3	4	4	4	4	5	4	4.11
A-2	4	4	3	3	5	4	5	5	5	4.13
A-3	4	4	3	3	5	3	5	5	5	4.00
A-4	5	4	4	5	5	3	4	5	5	4.44
A-5	4	4	4	5	5	3	4	5	4	4.22
A-6	5	3	5	5	4	4	4	5	5	4.44
A-7	5	4	5	4	5	4	5	5	3	4.38
A-8	4	4	4	4	5	3	4	5	4	4.11
A-9	5	4	3	4	5	4	5	5	4	4.25
A-10	5	4	5	5	4	3	3	5	5	4.33
A-11	5	4	5	5	5	4	2	5	5	4.44
A-12	5	4	5	5	5	3	2	5	5	4.33
B-1	5	5	3	4	3	4	4	2	4	3.78
B-2	4	4	3	3	4	4	4	2	3	3.44
B-3	4	4	3	4	4	4	4	2	4	3.67
B-4	4	3	3	3	3	4	4	2	4	3.33
B-5	4	4	3	3	3	4	4	2	4	3.44
B-6	5	4	4	4	4	4	5	1	5	3.88
B-7	5	4	3	4	4	4	5	1	4	3.63
B-8	5	4	3	4	4	5	5	1	5	3.71
B-9	5	4	3	4	4	4	5	1	5	3.75
B-10	5	4	3	4	4	4	4	4	5	4.11
B-11	5	4	3	4	4	4	4	2	5	3.89
B-12	5	3	3	4	4	4	5	3	5	3.88
C-1	4	4	4	5	5	4	4	5	5	4.44
C-2	5	4	4	5	5	3	4	5	4	4.33
C-3	5	4	3	5	5	4	4	5	5	4.44
C-4	5	4	5	4	5	2	4	5	5	4.33
C-5	4	4	3	4	5	2	4	5	5	4.00
C-6	5	4	5	4	4	4	5	5	4	4.38
C-7	4	4	4	3	5	4	5	5	5	4.25
C-8	4	4	4	3	5	4	5	5	5	4.25
C-9	5	4	3	4	5	4	5	5	4	4.25
C-10	5	3	4	4	4	3	4	5	5	4.11
C-11	5	3	3	4	4	3	4	5	5	4.00
C-12	5	3	5	4	4	4	5	5	5	4.38
D-1	5	3	3	4	4	4	4	5	3	3.89
D-2	4	4	3	4	4	4	4	5	3	3.89
D-3	4	4	3	4	4	4	4	5	4	4.00
D-4	5	4	3	3	4	3	4	5	4	3.89
D-5	5	3	5	4	4	4	4	5	4	4.22
D-6	5	4	5	4	5	5	4	5	5	4.63
D-7	5	4	5	4	5	4	4	5	4	4.44
D-8	5	4	5	4	5	4	4	4	4	4.33
D-9	4	4	3	4	5	4	4	5	5	4.22
D-10	5	4	3	5	4	4	4	3	5	4.11
D-11	5	4	3	5	4	5	4	3	5	4.13
D-12	5	4	3	5	4	5	4	3	5	4.13
E-1	4	4	3	4	4	4	4	5	5	4.11
E-2	5	4	3	4	4	4	4	5	4	4.11
E-3	5	4	3	4	4	4	4	5	4	4.11
E-4	5	4	3	4	4	4	4	5	4	4.11
E-5	5	4	3	4	4	4	4	5	4	4.11
E-6	5	3	4	4	4	5	4	5	5	4.25
E-7	5	3	4	4	4	5	4	5	5	4.25
E-8	5	3	3	3	4	5	4	3	5	3.75
E-9	4	4	3	4	4	5	4	5	5	4.13
E-10	5	4	4	4	4	4	4	3	5	4.11
E-11	5	4	3	4	4	4	4	3	5	4.00
E-12	5	4	3	4	4	5	4	3	5	4.00

In the process of getting the expert opinion useful feedbacks and advices were also obtained. Some feedbacks were the need to explain the meaning of certain terms used such as Cellular Layout, 5S, Visual Management. There were also feedbacks that some questions would be better off if some elaboration is made. As such after the exercise the questionnaires were reviewed taking into consideration all the feedbacks (Appendix 2 shows the final version). For a more wholesome opinion the experts opinion were sought from members in the case study site (n=5) who are not only familiar with supply chain but whose scope of work revolves around it (these consist of planners whose jobs are to ensure the operation runs uninterrupted through having the required materials at any one time, operation managers whose task is to make sure the resources are all in place and managers who oversee specific operations) ; those outside the case study site (n=2) who are basically working in the field of supply chain management but of another organization (these are also planners who have more than 10 years of supply chain management experience) ; academicians (n=2) who are lecturing in the field of supply chain management. For these members they are either working in the field of supply chain management or teaching this subject in the university (for the academicians' one is a Senior Lecturer and the other a Professor from the School of Management in Universiti Sains Malaysia). The selection of these personnel to give their expert opinions were required as part of the content validity covering both the item validity and sampling validity (Gay & Airasian, 2003; Zikmund, 2003; Hair *et al.*, 2006). It has to be noted that content validity is determined by expert opinion and that there is no standard formula by which it can be computed (Gay & Airasian, 2003).

3.8 Summary

This chapter outlined the processes involved in designing the research. It provides information on the population to be researched on as well as the explanation on the instrument used. Data Analysis technique was described which mainly is on the use of SPSS software. A pilot study conducted provides the research with the statistical data which shows that the result of the analysis should be accepted. Expert opinions were also sort to look into the content validity of the instrument used. Subsequently the next chapter will look into the result of the survey undertaken and from there discuss the research questions and test the hypotheses put forth.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter will capture the results of the research and will discuss at length the findings. The result would comprise mainly of the output of data input into SPSS as well as other informations gathered along the way.

4.2 Results

The data obtained from the research conducted through the self-administered questionnaire in the case study site was compiled and analyzed in September 2012 (survey period lasted about two months). This chapter reveals the detail of the 186 accepted responses (as elaborated in the last chapter).

4.2.1 Demographics of Study

The demographic of the case study site was tabulated through keying in each and every accepted response into the SPSS software. Table 4.1 shows the summary of the demographic characteristics.

Table 4.1

Demographic Characteristics

Category	Details	Frequency	Percent	Valid Percent	Cumulative Percent
Job Function	Operation	51	27.4	27.4	27.4
	Engineering	97	52.2	52.2	79.6
	Management	38	20.4	20.4	100.0
Education Level	Non Tertiary	78	41.9	41.9	41.9
	Tertiary	108	58.1	58.1	100.0
Age	21~30	71	38.2	38.2	38.2
	31~40	31	16.7	16.7	54.8
	>41	84	45.2	45.2	100.0
Years in Service	<2	46	24.7	24.7	24.7
	2~5	26	14.0	14.0	38.7
	6~10	12	6.5	6.5	45.2
	>10	102	54.8	54.8	100.0
Gender	Male	118	63.4	63.4	63.4
	Female	68	36.6	36.6	100.0
Race	Malay	44	23.7	23.7	23.7
	Chinese	116	62.4	62.4	86.0
	Indian	24	12.9	12.9	98.9
	Others	2	1.1	1.1	100.0

Vital information about the respondents as it relates to the study can be derived from the collective profiles. The population consist mostly of Engineers (52.2%) followed by those who are in Operation such as Production Supervisors (27.4%). Management group who oversee the various aspect of the organization comprise 20.4%. These are by category of their job functions.

In term of their education level it was found that majority (58.1%) have tertiary education. It was specifically stated that tertiary education level refers to those who have obtained a Bachelor, Master or a Doctoral qualification. As for the other 41.9% who are classified as non-tertiary, they are those who have High School, Diploma or a Certificate qualification.

As age is a sensitive matter to some, the researcher did not request for the absolute age but rather provides an age range for the individuals to respond. Nevertheless based on the respond it can be seen that the population in this case study site can be considered an aging population. This is because 45.2% are those who are above the age of 41. The next groups in term of size are those who are considered young. Their age falls in the region of 21~30 years old. Sandwich in between are those who falls in between these two groups.

As also reflected in the age, the population comprise of many who are long service members. In fact 54.8% are found to have served the company for more than 10 years. Apart from these the new employees (those with less than two years of service) form a considerable size (24.7%). In term of gender, more than half are male (63.4%). Female populations comprise 36.6% of the total population. For the racial breakdown of the said population, it consist of Chinese (62.4%); Malay (23.7%), Indian (12.9%) and others (1.1%). There are 3 respondents who are classified as "others". These are those who are from the minority Thai group.

4.2.2 Hypotheses Testing

For the cases where the hypotheses refers to the comparison of 2 groups the independent sample t-test was chosen while those comparing between groups greater than 2 will be analyzed using Analysis of Variance (Zikmund, 2003; Gay & Airasian, 2003, Coakes *et al.*, 2010). To recap the first hypothesis,

H_1 1 : There is a significant difference in employees' perceptions of Internal Supply Chain Performance between those with high exposure to Lean Practices and those with low exposure

Table 4.2 shows the means, sample sizes, standard deviations and standard errors for the 2 groups (by each dimension, research question and hypothesis).

Table 4.2
Group Statistics for Perception of Lean Practices

	Exposure to Lean	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Cellular Layout	Low	30	3.156	0.648	.118
	High	156	3.912	0.629	.050
5S	Low	46	2.870	0.879	.130
	High	140	3.776	0.660	.056
Visual Management	Low	31	3.097	0.481	.086
	High	155	3.807	0.625	.050
Teams	Low	36	2.806	0.634	.106
	High	150	3.793	0.608	.050
Organizational Structure	Low	52	2.904	0.538	.075
	High	134	3.766	0.581	.050
Lean Practices	Low	22	2.770	0.258	.055
	High	164	3.623	0.341	.026

The Independent sample t-test result for Lean Practices is shown in Table 4.3. Since the Levene's test has a probability greater than 0.05, we can assume that the population variances are relatively equal. As such the t-value, df and two-tailed significance for the equal variance estimates can be used (Coakes et al, 2010). For the t-test for equality of Means, the two-tailed significance value of 0.00 ($p < 0.05$) shows that there is a significant difference between the 2 groups. Based on this hypothesis H_1 1 is accepted.

Table 4.3
Independent Sample T-test Result for Those with High Exposure to Lean Practices and Those with Low (H_1 1)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.159	.691	-6.740	184.000	.000	-11.002	1.632	-14.222	-7.781
Equal variances not assumed			-6.838	27.188	.000	-11.002	1.609	-14.302	-7.701

Table 4.4 to Table 4.8 provides the breakdown by individual dimensions (research question and hypothesis).

Table 4.4

Independent Sample T-test Result for Those with High Exposure to Lean Practices and Those with Low Based on Dimension of Cellular Layout (H_1 1_a)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1.871	.173	-4.190	184.000	.000	-6.406	1.529	-9.423	-3.390
Equal variances not assumed			-4.608	45.092	.000	-6.406	1.390	-9.207	-3.606

Out of the 5 dimensions all are found to be significant. These dimensions that are significant refers to Cellular Layout ($p > 0.05$), "5S" ($p < 0.05$), Visual Management ($p < 0.05$), Teams ($p < 0.05$) and Lean Organizational Structure ($p > 0.05$).

With respect to H_1 1_a (Table 4.4), the result derived shows those with high exposure to Lean Practices (Mean = 3.912, Standard Deviation = 0.629) and those with low exposure (Mean = 3.156, Standard Deviation = 0.648), $t(184) = -4.190$, $p < 0.05$. As the significance level stands at 0.00 , hypothesis H_1 1_a is accepted. As such,

H_1 1a : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to Cellular Layout - is accepted.

Table 4.5
Independent Sample T-test Result for Those with High Exposure to Lean Practices and Those with Low Based on Dimension of 5S (H_1 1_b)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.078	.780	-6.072	184.000	.000	-7.560	1.245	-10.017	-5.104
Equal variances not assumed			-5.702	69.559	.000	-7.560	1.326	-10.205	-4.916

With respect to H_1 1_b (Table 4.5), the result derived shows those with high exposure to Lean Practices (Mean = 3.776, Standard Deviation = 0.660) and those with low exposure (Mean = 2.870, Standard Deviation = 0.879), $t(184) = -6.072$, $p < 0.05$. As the significance level stands at 0.00 , hypothesis H_1 1_b is accepted. As such,

H_1 1_b : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to 5S practiced - is accepted.

Table 4.6

Independent Sample T-test Result for Those with High Exposure to Lean Practices and Those with Low Based on Dimension of Visual Management (H_1 1_c)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.102	.749	-5.491	184.000	.000	-8.039	1.464	-10.927	-5.150
Equal variances not assumed			-5.189	40.763	.000	-8.039	1.549	-11.168	-4.910

With respect to H_1 1_c (Table 4.6), the result derived shows those with high exposure to Lean Practices (Mean = 3.807, Standard Deviation = 0.625) and those with low exposure (Mean = 3.097, Standard Deviation = 0.481), $t(184) = -5.491$, $p < 0.05$. As the significance level stands at 0.00 , hypothesis H_1 1_c is accepted. As such,

H_1 1_c: Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect Visual Management - is accepted.

Table 4.7

Independent Sample T-test Result for Those with High Exposure to Lean Practices and Those with Low Based on Dimension of Teams (H_1 1_d)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1.387	.240	-7.540	184.000	.000	-9.818	1.302	-12.387	-7.249
Equal variances not assumed			-8.170	58.886	.000	-9.818	1.202	-12.222	-7.413

With respect to H_1 1_d (Table 4.7), the result derived shows those with high exposure to Lean Practices (Mean = 3.793, Standard Deviation = 0.608) and those with low exposure (Mean = 2.806, Standard Deviation = 0.634), $t(184) = -7.540$, $p < 0.05$. As the significance level stands at 0.00 , hypothesis H_1 1_d is accepted. As such,

H_1 1_d : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to Teams- is accepted.

Table 4.8

Independent Sample T-test Result for Those with High Exposure to Lean Practices and Those with Low Based on Dimension of Organizational Structure (H_1 1_c)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.823	.365	-8.727	184.000	.000	-9.626	1.103	-11.802	-7.450
Equal variances not assumed			-9.009	99.285	.000	-9.626	1.068	-11.746	-7.506

With respect to H_1 1_c (Table 4.8), the result derived shows those with high exposure to Lean Practices (Mean = 3.766, Standard Deviation = 0.581) and those with low exposure (Mean = 2.904, Standard Deviation = 0.538), $t(184) = -8.727$, $p < 0.05$. As the significance level stands at 0.00 , hypothesis H_1 1_c is accepted. As such,

H_1 1_c : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to Lean Organizational Structure - is accepted.

4.2.3 Pearson Correlation

The correlation between Lean Practices (independant variable) and Internal Supply Chain Performance (dependant variable) was tested to see if these independent and dependant variables are related. For this the Pearson correlation was used to test this relationship. The result after running the test through SPSS shows the result as in Table 4.9.

Table 4.9
Pearson Correlation for Lean Practices and Internal Supply Chain Performance (H_1 2)

		Lean Practices	Internal Supply Chain Performance
Lean Practices	Pearson Correlation	1	.834**
	Sig. (1-tailed)		.000
	N	186	186
Internal Supply Chain Performanc	Pearson Correlation	.834**	1
	Sig. (1-tailed)	.000	
	N	186	186

**. Correlation is significant at the 0.01 level (1-tailed).

In order to test the hypotheses, this Pearson correlation test was conducted to see the association between the variables. Pallant (2001) suggested that when the value of the Pearson correlation is 0, it indicates there is no relationship, while a correlation of ±1.0 indicates that there is a perfect positive or negative relationship. In order to interpret the values between 0 (no relationship) and 1 (perfect relationship), Cohen's (1988) suggestion was used. When r = ±0.1 to ±0.29, the relationship is said to be small, when r = ±0.30 to ±0.49, the strength is medium while when r is ±0.50 and above, the strength is large.

Based on the above result it can be said that there is a bivariate correlation (Coakes *et al.*, 2010) between Internal Supply Chain Performance and Lean Practices. There is a

positive relationship between these two variables. Result of the correlation indicates that Internal Supply Chain Performance is associated with Lean Practices ($r = 0.834$, $p < 0.05$). As such,

H_1 2 : There is a significant correlation between Lean Practices and Internal Supply Chain Performance – is accepted.

4.2.4 Comparison of Perception by Gender

The research looks into the perception by gender to see if there is any significant difference in their views on Internal Supply Chain Performance. As the comparison for gender involves only 2 groups (Male and Female), the Independent sample t-test was used. Table 4.10 display the mean and standard deviations for the respondents and Table 4.11 shows that from there is no significance difference in the responds from the standpoint of gender ($p > 0.05$).

Table 4.10
Group Statistics for Respondents by Gender

Education Level	N	Mean	Std Deviation	Std Error Mean
Male	118	3.604	.530	.049
Female	68	3.679	.541	.066

Table 4.11

Independent Sample T-test Result for Respondents Based on Gender

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.005	.943	-.928	184.000	.354	-.075	.081	-.236	.085
Equal variances not assumed			-.923	137.384	.358	-.075	.082	-.237	.086

H_1 3a : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of gender – is rejected.

4.2.5 Comparison of Perception by Job Function

In the earlier explanation, the composition of the respondents is shown from the standpoint of demographics of their job function. Further analysis was carried out to confirm whether the respondents have any significant difference in their perception of internal supply chain performance by virtue of their job function. In order to do this comparison Analysis of Variance (ANOVA) was carried out since it entails the comparison of means for groups greater than 2.

The result as in Table 4.12 and Table 4.13 shows that there is no significant difference ($p > 0.05$) in the perception of the respondents regardless of their job function. Since there is no significant difference Post-hoc analysis to further scrutinize the data for any significance would not be carried out (Coakes *et al.*, 2010).

Table 4.12
Test of Homogeneity of Variances for Respondents by Job Function

Levene Statistic	df1	df2	Sig
1.197	2	183	0.304

Table 4.13
ANOVA for Respondents by Job Function

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.466	2	0.233	0.816	0.444
Within Groups	52.229	183	0.285		
Total	52.695	185			

As such,

H_1 3b : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of job function – is rejected

4.2.6 Comparison of Perception by Length of Service

The population has been segregated in terms of how long they have served in the organization. ANOVA test was carried out to see if the length of service has any bearing to their perception of Internal Supply Chain Performance.

Table 4.14
Test of Homogeneity of Variances for Respondents by Length of Service

Levene Statistic	df1	df2	Sig
.390	3	182	.760

Table 4.15
ANOVA for Respondents by Length of Service

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.251	3	.417	1.475	.223
Within Groups	51.444	182	.283		
Total	52.695	185			

From the ANOVA test it can be seen that there is no significant difference in the mean of the perception of respondents with respect to their length of service. This can be seen in Table 4.14 and Table 4.15 where $p > 0.05$. As such,

H_1 3c : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of length of service – is rejected.

4.2.7 Comparison of Perception by Sections

Basically the population has been categorized into 2 different sections with regard to where they work. To see if there is any significant difference in their perception in terms which section they work in, independent sample t-test is carried out. Table 4.16

display the mean and standard deviations for the respondents while Table 4.17 shows that there is indeed a significant difference in the perception of Internal Supply Chain Performance with regard to the section the respondent works in.

Table 4.16
Group Statistics for Respondents by Sections

Education Level	N	Mean	Std Deviation	Std Error Mean
Section 1	103	3.711	.495	.049
Section 2	83	3.533	.566	.062

Table 4.17
Independent Sample T-test Result for Respondents Based on Sections

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	2.941	.088	2.297	184.000	.023	.179	.078	.025	.332
Equal variances not assumed			2.264	164.001	.025	.179	.079	.023	.335

As such,

H_1 3d : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of section – is accepted.

4.2.8 Comparison of Perception by Race

Since the comparison by race involves groups greater than two, ANOVA test was carried out.

Table 4.18
Test of Homogeneity of Variances for Respondents by Race

Levene Statistic	df1	df2	Sig
.390	3	182	.760

Table 4.19
ANOVA for Respondents by Race

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.461	3	.154	.536	.658
Within Groups	52.234	182	.287		
Total	52.695	185			

Table 4.18 display the mean and standard deviations for the respondents and Table 4.19 shows that from there is no significance difference in the responds from the standpoint of race ($p > 0.05$). As such,

H_1 3e : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of race – is rejected.

4.2.9 Comparison of Perception by Level of Education

As the comparison for level of education involves only two groups (Tertiary and Non-Tertiary), the independent sample t-test was carried out. Table 4.20 display the mean and standard deviations for the respondent.

Table 4.20
Group Statistics for Respondents by Education Level

Education Level	N	Mean	Std Deviation	Std Error Mean
Non Tertiary	78	3.714	0.592	0.067
Tertiary	108	3.572	0.481	0.046

Table 4.21 shows that there is a no significant difference ($p>0.05$) when it comes to the perception of the respondents by education level though those who are from non tertiary education level have a higher mean compared to those who are from tertiary level.

Table 4.21
Independent Sample t-test Result for Respondents based on Education Level

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	5.757	.017	1.794	184.000	0.074	0.141	0.079	-.014	.297
Equal variances not assumed			1.736	144.376	0.085	0.141	0.081	-.020	.303

As such,

H_1 3f : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of educational level – is rejected.

4.2.10 Summary of Hypotheses

Summary of the hypotheses tested is tabulated as in Table 4.22.

Table 4.22
Summary of Hypotheses

Hypotheses	Accept / Reject
H_1 1 : There is a significant difference in employees' perceptions of Internal Supply Chain Performance between those with high exposure to Lean Practices and those with low exposure	Accept
H_1 1a : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to Cellular Layout	Accept
H_1 1_b : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to 5S practiced	Accept
H_1 1_c: Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect Visual Management.	Accept
H_1 1_d : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to Teams	Accept
H_1 1_e : Between those with high exposure to Lean Practices and those with low exposure, there is a significant difference in employees' perception of Internal Supply Chain Performance with respect to Lean Organizational Structure.	Accept
H_1 2 : There is a significant correlation between Lean Practices and Internal Supply Chain Performance	Accept
H_1 3_a : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of gender	Reject

Table 4.22 (Continued)

H_1 3_b : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of job function	Reject
H_1 3_c : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of length of service	Reject
H_1 3_d : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of section	Accept
H_1 3_e : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of race	Reject
H_1 3_f : There is a significant difference in employees' perceptions of Internal Supply Chain Performance in terms of educational level	Reject

4.3 Discussion

With the result obtained as in the sub-section 4.2 this portion on discussion will dwell on whether the result of this study support the hypothesis quoted. It will also discuss the inputs from the interviews and observations in the light of the empirical findings.

4.3.1 Does Lean Practices have a Significant Effect on Employees' Perceptions of Internal Supply Chain Performance?

The answer to whether lean practices have a significant effect on employees' perception of Internal Supply Chain Performance is affirmative. As the result from the survey carried out (self-administered questionnaire) shows, the first hypothesis related to the research questions was accepted. It was thus concluded within the scope of the case study site that there is a significant difference in employees' perceptions of Internal Supply Chain Performance between those with high exposure to Lean Practices and

those with low exposure. The average mean for these two groups are 3.623 and 2.770 respectively.

The greater mean for those with high exposure to lean practices would likely be attributed to the fact that the respondents sees the positive effect of lean practices and associating it with the improved internal supply chain performance. Furthermore the various test using independent sample t-test and ANOVA shows that the responses received were independent of their demographics details such as,

i. The gender of the respondents. Regardless if whether they are male or female the responds is consistent (H_1 3_a). also did not show any significant difference when it comes to the perception of the respondents
ii. The type of job function (whether they are in Engineering, Operation or Management) they perform (H_1 3_b)
iii. The length of service of the respondents. It can be seen that those who serves in the organization less than 2 years till those who exceeds 10 years do not display a significant difference in their perception (H_1 3_c).
iv. The race or ethnicity of the respondents. In a multi-racial society like Malaysia the result shows that the perception of the people working there is independent of their race (H_1 3_e).
v. Similarly it was found that those who do not have tertiary education (High School, Diploma or Certificate) and those with tertiary education did not show any significant difference in their perception (H_1 3_f).

There is however statistically a significant difference in the perception of the respondents with regard to the internal supply chain performance when analyzed from

the angle of which section they work in. It was found that those who works in Section 1 shows a higher mean (3.711) compared to those from Section 2 (3.533). This result conveys the message that the area a person works in influence their perception significantly.

Through conducting interviews and facts compiled from documents in the said site the researcher was able to summarize them to show the effect before and after lean practices implementation. Details of these are shown as cases.

A) Case 1 relates to a project called "LSPS Lean Project" where employees from Section 1 were involved. In this project the said product (LSPS) line has a history of long turn-around-time (TAT). With the prospect of rapid production expansion this product line has been requested by top management to consider how they could reduce the TAT through lean implementation. The TAT during start of project stands at 276 hours (measured by tracking the time it takes for the product to flow from beginning of the process flow till shipment). Below are some of the many issues identified by the working group together with the help of an external consultant employed by the company.

i. There seems to be a lack of WIP management as evident from the high WIP level. Consciousness of the detrimental effect of excess WIP is almost non-existent. Furthermore those working at the shop floor were not aware of their WIP level as they are just "busy" producing products. The working group was thus tasked with the job of educating and making the WIP situation visible. This talks about visual management where effort to make the WIP level clear is important. Some proposals were put forth such as making

display boards to show the WIP level on a shift basis, using the ICT available and make WIP reports that display real time level for all in the shop-floor to view, making simple controls using physical storage (example if the target WIP is 10 lots then the line could allocate a physical shelf that holds only a maximum of 10. In this way once the WIP reaches the 10 lots control the information can be escalated to higher management for appropriate action). Kanban (a card system to pull products) system (Singh, 2010) was introduced at critical processes so as to ultimately achieve a stable production where output is consistent. This works by pulling the required number of lots from previous processes because the cards represent the number of lots wanted.

ii. Layout especially in the End of Line (EOL) process was rather long. Based on measurement the total length of the EOL is 105m. After many rounds of brainstorming a possible future state layout was drafted that could reduce the length to a mere 40m. However to achieve the desired state the company need to spend more than RM 100,000 for relocation work. In order to justify the necessity of spending this money the working group made a proposal showing a favorable return on investment (ROI) to convince top management on the benefit of making the layout change (finally the top management agreed to the proposal and the change was subsequently executed).

iii. When going through the operation, the consultant noticed and highlighted the long time taken for lots or product changeover time. There is lack of awareness among the shop-floor members on how the long changeover time affects the company's bottom line. Furthermore it was observed that the

situation was made worst with poor 5S. It was common to see the operators wasting precious time searching for stationeries such as calculators; staplers etc due to the fact that it is placed at none specified places. An example observed was in the EOL process where the operators take 20 minutes to changeover from an old lot to a new lot. A detailed industrial engineering studies shows that essentially the whole operation could be completed in 3 minute if done without excessive waste. This has big implication on the machine capacity as during the changeover the machine remains idle. Taking into consideration the expensive nature of machines the loss is very substantial to the company. The line was advised to form cross functional teams to reduce the changeover time not only in EOL but the entire process. To do this a program called Single Minute Exchange of Die (SMED) which was made famous by Shingo (1985) was proposed and ultimately adopted.

iv. It was also observed that much time is wasted in communicating among the many supervisors responsible the entire line. It not only is tedious and time consuming but the quality of communication is doubtful as can be seen by many cases of errors made with root cause being unclear instructions. Towards this end the consultant proposed a lean organizational structure to the line whereby the personnel in charge would be arranged by product line rather than process based. Originally resistance to the proposal was evident as this change requires the personnel to be knowledgeable in more processes. Nevertheless the proposal was finally adopted after assuring the members that it will be beneficial for them too in that they will learn new things. This change is much in line with the work by Pinheiro (2010) where he advocates

vertical organizational structure against the conventional horizontal organizational structure in a lean implementation.

After undergoing the lean implementation which entails many studies and improvement items, the TAT finally reduced to 152 hours (45% improvement) against an original target of 160 hours. 5S in the line shows clear improvement with most of the items required for work in its place (not only are the items labeled but the maximum quantity is also specified). It obeys the guideline given which is "a place for everything and everything in its place". In fact periodic check on 5S carried out by top management shows good result by this line. At the EOL process the operators were now able to improve on their productivity with the new layout where process length was reduced by 62%. SMED groups managed to reduce the changeover time impressively. For example in the EOL process the changeover time was reduced from 20 minutes to 7 minutes and finally at the time of this writing it has gone down to only 3 minutes. Human productivity registered an improvement of 10%. With the now clear visibility of WIP the level has shown an impressive reduction by 55%. On the machine performance, activities such as the SMED team activity and other improvements contributed to an 11% increase in Overall Equipment Efficiency (OEE). This was achieved within a period of 9 months (details of the project are shown in Appendix 3). The Table 4.23 below summarizes the projects before and after implementation while Figure 4.1 shows the LSPS Lead Time trend for before and after implementation.

Table 4.23

Summary of LSPS Lean Project

	Key Performance Indicators	UOM	Before	After	Effect
LSPS LEAN PJ	OEE	%	72	80	11%
	TAT	Hrs	276	152	45%
	WIP	Days	20	9	55%
	Human Productivity	Kpcs/hr	0.057	0.063	10%
	Process Length (EOL)	m	105	40	62%

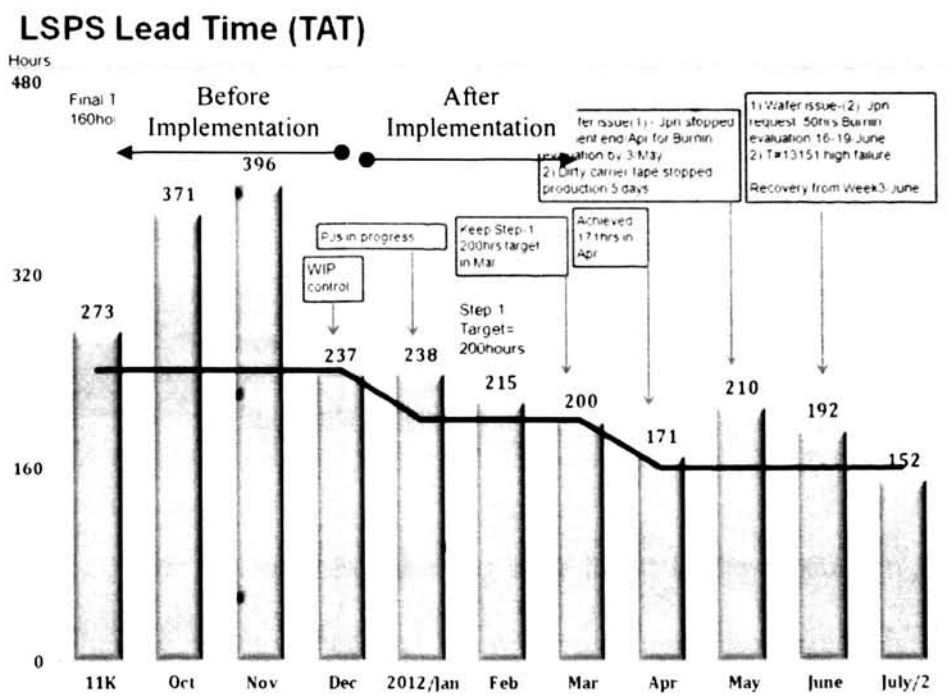

Figure 4.1

LSPS Lead Time or TAT

B) Case 2 - "LFPAK Lean Project". Due to the increased customer demand for this product (LFPAK is one of the major products produced in the case site), the management decided to put in resources for lean implementation so as to ultimately reduced its long TAT which has come under scrutiny and criticism from both within and without the organization. One pressing need to fend off competition is the need to be able to deliver products in the shortest time possible. A working group was formed and together with the help and

guidance from a Japanese based consultant, a study was carried out to make clear on the issues and propose a solution. Several issues were brought up and discussed such as,

i. Layout follows a job shop concept where machines of the same process are cluttered together in a shared area. This means that in a process called "A" all the machines related to process "A" are located there regardless of the package type. The working group was advised to work on a proposal to change the layout from a job shop to a flow shop (Singh *et al.*, 2010) whereby in a specified working area machines from multiple processes but of the same package type are assembled. This would result in a focused working area for this product line and should be able to reduce the walking distance and time drastically.

ii. Some raw materials were found in the production line occupying a big space and upon confirmation discovered that these materials stocked up could last a whole week. There is no clear visibility on the material stock such as whether from a glance the stock is sufficient or otherwise. Proposed solution given was for the group to consider using the Kanban card system (Mortimer, 2008; Singh *et al.*, 2010) to pull in the material as and when needed. The material stock was requested to be drastically reduced and to be replenished every shift. In this way a big production floor space could be potentially freed up.

iii. Some jobs were found to be poorly designed thus causing stress to the operators. The group was advised to make a work study on some critical processes so as to simplify the operators work procedure (Shingo,1989; Towill, 2010).

iv. The lot size was found to be rather large. This resulted in the long processing time as well as high TAT. In addition WIP continues to be high and is partially due to the large lot size. As such the group was advised to reduce the lot size to an optimal quantity (Lovell, 2003).

v. In the work study of processes, priority is given to those that are bottleneck in term of capacity. This concurs with the theory of constraint (Goldratt, 1990) where it states that at any one time there is at least one bottleneck that limits the whole process. By concentrating on these constraint points productivity improvement becomes evident

After taking the appropriate measures recommended as well as many more which the working group initiated, the lean implementation saw improvements of TAT from 168 hours to 36 hours, an impressive 79% reduction. This was achieved in a time frame of 1 year with all the aspects of lean practices mentioned in this research. Process length was drastically reduced from 947 feet to 162 feet (83% reduction). This was also measured by operator's steps where the measurement shows the operator's steps reduced from 2107 steps to only 421 steps (a reduction of 80%). Human productivity naturally improves through reduction of waste such as excessive walking and many

more work simplification. The index for human productivity sees an improvement of 22% (2.36 hrs/kpcs to 1.85 hrs/kpcs). At the same time the inventory or work in progress (WIP) level reduces from 7.3 days of stock to 3.6 days (50% reduction).

Table 4.24 shows the summary of the effect of this project while Figure 4.2 shows the Lead Time or TAT trend and some of the key improvement items. Appendix 4 shows the highlight for this LFPAK Lean Project.

Table 4.24
Summary of LFPAK Lean Project

	Key Performance Indicators	UOM	Before	After	Effect
LFPAK LEAN PJ	TAT	Hrs	168	36	79%
	Operators' Steps	Steps	2107	421	80%
	WIP	Days	7.3	3.6	50%
	Human Productivity	Kpcs/hr	0.443	0.54	22%
	Process Length	m	947	162	83%

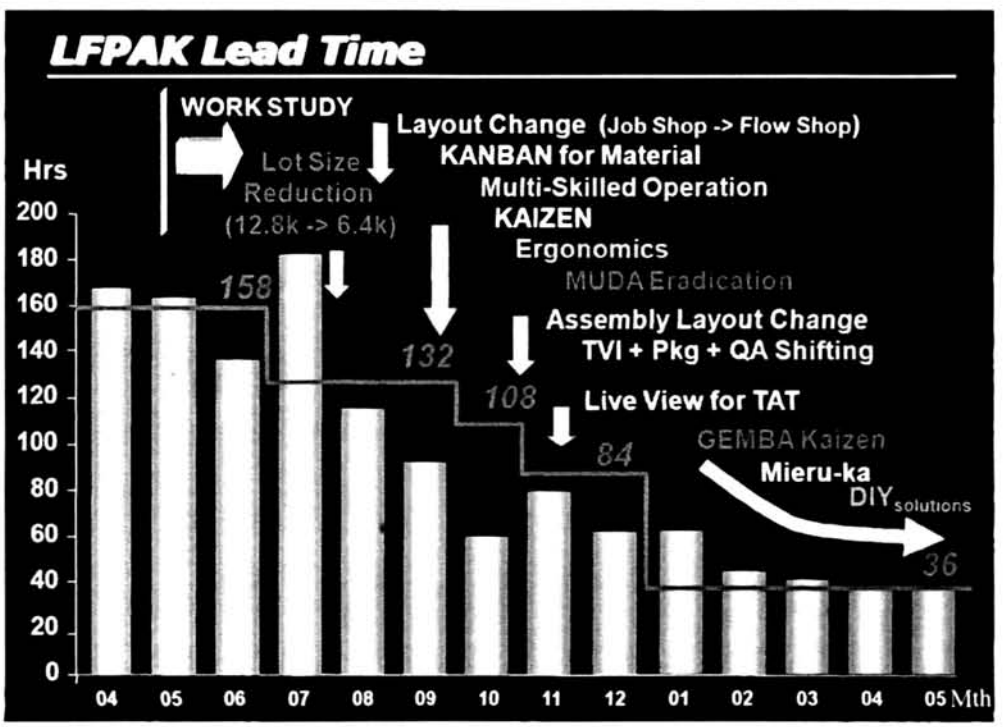

Figure 4.2
LFPAK Lead Time or TAT

C) Case 3 – "PwTrs Lean Project". Background for this project lies with the many complaints received from customers, visitors and top management on how messy the product line is. A baseline study shows that 40% of the production floor in this place was occupied by product storage. Products are literally kept all over the place and method of storage was also not standardized. Products are moved from one point to another with much difficulty as each container weighs about 20 kg. Design of trolleys and workstation are generally non ergonomic friendly. WIP is extremely high and visibility management is almost non-existent. Products are held back for all kinds of problems and there is no sign of first-in-first-out (FIFO) system. Obviously the TAT was long and there was no activity planned to improve it. Morale was low as working condition is not conducive, particularly in the area of having to carry the heavy containers. Due to the way workstations are layout the average walking distance for a typical operator was about 1500m per shift (this coupled with the need to carry a 20 kg container every 20 minutes makes it a tough job). A consultant was engaged to work together with the staffs in this product line to implement lean concepts with aim of improving the key performance indicators there. The group identified various areas of weaknesses and after prioritizing them the issues were sort out one by one.

i. 5S is definitely a big issue as can be seen by the non organized way products are stored. Going into more details shows poor 5S in material and parts storage. Work area too did not reflect an organized workstation. Towards this end the line was requested to work out a plan to improve on 5S starting with basic education as to why it is so important and how it can help in improving the work condition to the

benefit of the staffs themselves. Thereafter the plans were executed. The actions cover activities such as removing or disposing none required items be it an equipment or a fixture. This by itself can free up much space. A thorough cleaning up was carried out to clear the place of dirty areas, dusty areas, stains etc. Space was allocated for required items and they are labeled visibly. In areas where more space is required, options of reducing the fixtures such as workstations, trolleys etc were made. One of the reasons why the line was so congested was because it used re-cycled fixtures such as oversized tables that are not customized to the line's need. After having reduced what was obvious a relay-out was made to improve the overall 5S.

ii. Industrial Engineers were then tasked with the challenge of how they could solve the issue of having to move such heavy containers from one point to another. Impressively they were able to come up with unique proposals after working together with the shop floor members (by forming teams to discuss and brainstorm). An important point why they are able to come up with the unique idea was because of the fact that they were doing their investigation at the site of work rather than in the office. This attest to the effectiveness of a TPS teaching known as Genchi Genbutsu which talks about the need for people to solve problems at the actual place to see what is really going on (Liker, 2004). With the unique idea the task of carrying products was solved through use of conveyors. At the same time issues of poor ergonomics were addressed through re-design of

workstations. This idea was also used successfully in the case study site as reported by Kocakulah *et al.* (2011) which they described as "flow racks".

iii. The WIP level in the line was way too high and in fact there is no active monitoring of the WIP level to show the shop floor members. Apart from making visible the WIP situation, the consultant also discussed on how the process could be changed from a job shop concept to a flow shop concept using the conveyor system discussed earlier. The end result was the processes were literally re-designed into a straight line using conveyors and a flow line was achieved. With this the processing time also reduces and the WIP level dropped. A good point to note was that in the implementation of the flow line concept simulation was carried out off line together with the shop floor members. In this way many issues were able to be highlighted and addressed in the design itself. For example due to long length of the new conveyor the walking distance for some operators will be rather long. This was addresses by designing a simple "bridge" that can be shifted away when an operator wants to walk through the conveyor area.

iv. In the execution of this project many innovative ideas were obtained via the shop floor teams (Kaizen Innovative Teams). An important lesson learnt was that with the bottom up suggestions given implementation is made much easier.

Overview of the project sees four processes successfully linked together using a Do-It-Yourself conveyor system. This resulted in space saving of 20% (112 m^2), 60% reduction in walking steps (from 327 steps to 127 steps), elimination of lifting job especially in view of the heavy product containers (20 kg per container) through use of conveyor and improved visibility of work in progress. TAT was improved from 27 hours to 15 hours, an improvement of 44%. Such improvements are quite similar to some documented by other researchers such the one in United Kingdom where the electronic factory saw reduction in WIP, TAT and productivity by implementing flow in-place of the conventional batch (Mortimer, 2006). A summary of the improvement in this case is shown in Table 4.25. Appendix 5 showcases some highlights for this PwTrs Lean Project.

Table 4.25

Summary of PwTrs Lean Project

	Key Performance Indicators	UOM	Before	After	Effect
PwTrs LEAN PJ	TAT	Hrs	27	15	44%
	Walking Steps	Steps	327	127	61%
	Production Floor Space	m^2	525	413	21%

D) Case 4 – "COMBO Lean Project". This COMBO line is unique in that the products are customer specific. Demands especially from the customers are severe as the supply chain would be severely affected if this organization is not able to deliver what they need and when they need. On the other hand this organization is keen to do business with the said customers as they pay a premium price for the product. Due to the request for shorter and shorter TAT by the customer a Lean Project was initiated. A working group was formed to implement relevant lean practices so as to reduce the TAT drastically. In fact

the target given was to reduce it by 50% within a time frame of 1 year. Among the issues and proposals made, the main ones are,

i. Waste of transportation is observed in many areas particularly in the end processes. The basic reason is due to the way machines are layout. Historically the line has been adding new machines every once in a while by just filling in any available space without consideration of people and product movement. This through the years has taken a toll on the people and product flow resulting in much waste that has become in-grain. Proposals that were made are to relay out machines by taking into consideration people and product flow. This exercise was carried out though it is tedious and requires some amount of financial resource. However after making the changes the line was able to benefit and this reflected in the KPI for this product line.

ii. Wire Bond (a process where gold wire are used to bond onto the chip) process was found to have a very long processing time of 12 hours per lot. This is the longest processing time in the total process from FOL to EOL. In order to improve on the processing time a study was made to bond a single lot using 2 machines instead. This was tried out and successfully implemented with a drastic reduction from 12 hours to only 6 hours to produce one lot. Since this change requires modification in work procedure the use of teams (Kaizen Innovative Team) was important in getting feedback and suggestions on how it could be implemented.

iii. In order to help the shop-floor members to visualize the high WIP situation, simplified Value Stream Mapping (VSM) was made as part of the effort to educate the people working in this product line. This simplified drawing is able to display the number of lots in each process and to show its excessiveness as the theoretical TAT could be forecasted based on the number of lots available in each process.

iv. By walking through the line one can see many problem lots kept in many places. These problem lots do not get escalated up to higher management and could even be kept for more than 100 days. An interesting proposal was made to make things in the line more visible. This was by removing partitions and was carried out in many areas for this product line. By doing so problems (especially problem lots) are exposed and this allows for appropriate actions. This is in line with TPS teaching where Liker (2004) talks about Principle 7 of Toyota Way which says to use visual control so no problems are hidden.

v. Another form of visibility which also is lacking is the virtual reports. Towards this end the groups was tasked with making a few key virtual reports and having these reports displayed on big LCD screen.

vi. Bottleneck machines were identified and throughput improvement activities were carried out after having done a work study there. This is much similar to what Taj & Berro (2006) did where they applied the

constrained management so as to make clear the bottleneck and ultimately improving on the throughput. After identifying the bottlenecks teams using SMED were given the task of improving the changeover time for these critical machines.

After taking many steps to improve this product line, the TAT for this case improved from 199 hours to 100 hours (50% reduction) within a time frame of 1 year thus meeting the top management's expectation. The WIP level also shows a 50% reduction from 10.8 days on average to only 5.4 days of stock. As the project involves making a unique workstation, space was freed up for more productive use (47 m^2). Productivity at one of the bottleneck process improves by 28% after implementing various measures recommended after a work study (112 Kpcs per shift to 143 Kpcs per shift). Processing time at the Plating machine (which is a critical machine) also shows drastic improvement from 251 seconds per lot to only 79 seconds (an improvement of 68%). For this project the company realized a tangible savings of RM 23,000 per month. Table 4.26 summarizes the effect of this project whereas Figure 4.3 shows the TAT trend for COMBO and the various activities carried out (May onward are the data for after implementation). Appendix 6 shows the highlights for COMBO Lean Project.

Table 4.26

Summary of COMBO Lean Project

	Key Performance Indicators	UOM	Before	After	Effect
COMBO LEAN PJ	TAT	Hrs	199	100	50%
	WIP	Days	10.8	5.4	50%
	Productivity (CFM)	Kpcs/Shift	112	143	28%
	Productivity (Plating)	sec/lot	251	79	68%
	Free up space	m^2	-	47	-

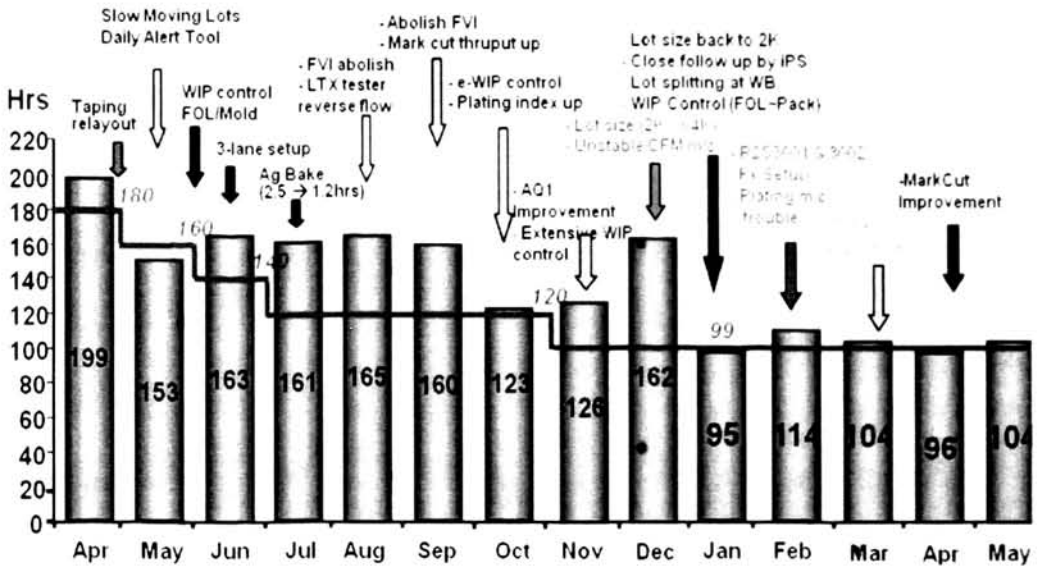

Figure 4.3

COMBO Lead Time or TAT

All these cases (and many more not quoted) bring about improvements in the internal supply chain performance such in that it allows for.

i. Supply chain flexibility. By virtue of improving the productivity margins in almost all the cases, the product lines were able to accommodate changes in the ever increasing customized demands such as one customer wanting a particular specification while another has their own. Many innovative ideas were generated through teams in the cases mentioned, where supply chain flexibility can be

achieved. An example was how in Case 1 the packing process was able to accommodate multiple customer packing methods. That one station was installed with a computer wherein all that the operator needs to do is just scan the part name and a picture of how the product need to be packed is displayed. For the operator they just follow the instruction on the computer. The trend of customers requiring more and more variety demands a respond for supply chain flexibility (Duclos et. al., 2003). Another research saw the author giving 18 principles in lean implementation so as to achieve flexibility and integration in the supply chain (Ranky, 2007).

ii. Supply Chain Integration where like the project in "PwTrs Lean Project" the process was transformed from a job shop to a flow shop using a conveyor system. In this way the processes were integrated together with operators at close proximity, which in the final analysis helps in achieving a high level of communication and coordination (Appendix 5 and Appendix 7). In Case 2 the LFPAK product line was able to consolidate its dispersed processes into a small operation area (Appendix 4) without any capacity loss. Processes formerly located in different rooms were now placed in a common room and formerly dedicated operators were now replaced with multi-skilled operators. Communication improves drastically as being physically in the same room allows for clear and accurate communication. Based on interview the incidents of miscommunication reduced (though no exact empirical data is able to be shown).

iii. Customer Responsiveness was achieved in every case as the TAT reduces drastically. The effect of this reduced TAT meant that the product line is able to react fast to customer request and keep to the order time promised. Example of how customer responsiveness is achieved is in the case of LSPS (Case 1) where the changeover time for the bottleneck process was reduced from 20 minutes to only 3 minutes. With the short changeover time there is no burden in having frequent change in tandem with customer requirements. Reduction in the changeover time is an important activity under SMED Workshops where cross functional teams comes together and target to reduce their changeover time by 50%. Actual result based on interviews with managers and engineers shows that an average of 51% change-over time was achieved in the last one year. Appendix 8 shows the SMED activity and its result.

A point to note is that in each and every case after achieving their good result there is always a celebration where the result can be showcased to other departments so as to have horizontal deployment. It also is a powerful way to create awareness on the benefit of implementing lean which in a way can be seen by the obvious survey results where it shows that those who are exposed to lean practices have a more positive perception on its benefits.

Such results as mentioned in the cases are not uncommon in lean implementation. Research such as the one on building a high-commitment lean culture shows that the productivity improves with lean implementation (Angelis *et al.*, 2011). In the research on how lean implementation affect the newspaper production it was also shown to be positive with reduction of waste or muda, reduced inventory and reduced changeover time (Engum, 2009) etc.

In the case study site, the CEO commented that lean implementation has resulted in the organization being able to improve in most key performance indicators, thus giving it the competitive advantage in the business. Improvements in process which results in a faster flow of the products meant that the TAT would reduce and thus allows for a shorter order time. This improves the customer satisfaction as they would now wait for a shorter period. It also is a great help in meeting urgent customer requests. A shorter TAT also meant that there will be lower inventory which not only reduces the holding cost but it allows for problems to emerge instead of being hidden by high inventory. In fact this is one of the 14 Toyota principles (Liker, 2004). In the long run quality will improve as problems get solved instead of hidden. As a result of much problem solving, the productivity naturally improves as can be seen in the cases quoted. After many rounds of improvement or "Kaizen" (Continuous Improvement) integration often comes about. This could be in the form of merging of processes or abolishment of processes (as in the case 3 where several processes were linked together). Apart from reducing the time taken, integration of processes would also improve the communication, not only because the processes are physically close together (though this also help) but because of the mere reduction of the number of personnel requiring to be communicated to.

4.3.2 Does the Implementation of Cellular Layout have a Significant Effect on Employees' Perception of Internal Supply Chain Performance?

Cellular layout is generally a common practice in areas where lean is implemented. The result did show a significant difference in the perception of those who have high exposure to lean practices compared to those with low. It could be that the respondents sees numerous cases of how the cellular layout made a difference (as described in the cases earlier on) in the operation area that they perceived it to be effective in improving

the internal supply chain performance. At the site feedbacks from respondents through interviews reveals various positive effects of cellular layout. Examples are,

i. As in the LSPS Lean Project, three separate processes were able to be re-layout into a cell thus effectively merging them into one process. With this the process length reduced drastically for the affected area (from 105m to 40m – a reduction of 62%). This reduction in physical space and length ultimately reduces lots of waste (or muda) such as transportation time due to too much walking, and motion due to non ergonomic friendly design of work station. Even areas allocated for inventory in the layout are calculated and allocated so as to discourage over-production. (Refer to Appendix 3). Kocakulah *et al.* (2011) gave an example of how this concept was also utilized in their case study site where layout changes were made to incorporate cell design of a workspace. With the change they were able to bring their operations near to each other in a U-shape fashion so as to reduce time between operations. In that case a 14% productivity up was registered.

ii. In a separate situation, off-size fixtures such as work station were used. The initial reasoning was that the off-size fixtures have no additional cost since it was re-cycled. However by merely re-cycling this non-ergonomic friendly as well as excessive size workstation, much waste (muda) was incorporated into the system. These are in such waste as needing to have extra motions, walking, bending etc due to the design of the workstation. Much improvement was seen once through the lean initiative a new workstation was designed and implemented (refer to Appendix 5). The workstation addresses the weaknesses identified and allows not only improved TAT but

also human productivity and morale of operator. This kind of improvement concurs with other studies such as the one on geometry of workspace (Boutellier *et al.*, 2008) where it shows optimization of space can be achieved with proper studies.

Just as the perception of the respondents are significant for this case study site other studies also did concurs with it, such as the effect of the physical flow improvement due to layout change from process layout to cellular layout by Cagliano et. al. (2006). It is also appropriate to mention that research on best practices in manufacturing to achieve supply chain flexibility using layout strategy (though not necessarily cellular layout) has been acknowledged (Boyle, 2006). Some common comments pertaining to how cellular layout affects internal supply chain performance during the interviews are captured below:

"When demand changes the number of cells can be adjusted to fit the demand"

"With multi-skill the shop-floor members could now enlarge their job scope. Though skill up time takes longer then before, the overall benefit of operating a cell with different varieties of machine provides a mutual benefit to both management and operators."

"Cellular Layout reduces WIP as it restricts the space allowed for storage. In this way when WIP builds up it becomes evident and the situation is escalated up. With less WIP TAT shortens and the cash flow improves as total WIP now reduces and thus holding cost is down."

"Not only cellular layout improves the product flow. Even our conventional layout also improves the flow"

More comments in the interview are captured in Appendix 9.

4.3.3. Does the Practice of 5S have a Significant Effect on Employees' Perception of Internal Supply Chain Performance?

Good housekeeping makes good business sense. The overall productivity of a workplace can be substantially affected by good housekeeping but often time this important aspect is given low priority. Apart from improving productivity (which results in improved internal supply chain performance), good housekeeping reassures customers and potential customers that their products are being taken care of (Cohan, 1985). The result in this research concurs with such findings as can be seen by the significant difference in perception of those who have a high exposure to lean practices compared to those with low exposure. Support for practice of 5S having a positive effect on the internal supply chain of a lean implementation was advocated in researches done in various places apart from Japan (where it is widely practiced (Gapp *et al.*, 2008) such as in Mexico in some latest research (Manuel & Juan, 2012), Spain (Alberto, Alejandro & Javier, 2010). A dissertation work in USA on 5S also showed how 5S was correlated to productivity, Cycle Time (or TAT) and quality improvement in the electrical industry (Lynch, 2005). Based on observation and interviews the researcher was able to obtain feedbacks such as these.

i. Workstations in Section 1 generally have clear indications demarcating where any particular item need to be placed. These are often indicated

clearly and in some cases even photo showing how items should be arranged are displayed for shop-floor members. Maximum quantities are also specified so that there is no overflowing of material. True to the guidelines given, it can be observed in Section 1 that the practice of "A place for everything and everything in its place" (Imai, 2001) is faithfully carried out. Not only is the workplace more presentable but the sheer practice of 5S improves productivity especially in eliminating the waste of having to search for required things such as tools, material, jigs etc. This makes good sense in ensuring that the operation runs smoothly and is flexible. In today's environment multiple product types is common and as such daily changeover expected. In order to do so (to ensure customer delivery is kept) 5S is a key practice. Time to perform changeover could be reduced by at least drastically through having all required items in its right place, right quantity and right time. Appendix 10 show examples of 5S practiced as well as basic explanation on what 5S is all about in the case study site.

ii. It can be observed in the production floor that machines are typically arranged in an orderly way where for example all front part of machines are aligned (rather than aligned to the backside). In this way waste of motion can be reduced as each additional step used is considered as muda. (Appendix 11 shows how the machines are layout in the case study site).

iii. One basic aspect of 5S is the need to throw what that is not necessary (Seiri). Evidence of this can be seen where unutilized equipments were tagged and removed from the production floor. This free up the space for more

equipment which can add value. In-fact the habit of some to horde excess equipment hinders good 5S and creates redundancy apart from making it difficult for expansion without creating new buildings. By removing excess machines the remaining ones could be re-arranged (Seiton) so as to further improve on its internal supply chain performance.

iv. With the implementation of lean practices it can be seen that there is periodic cleaning taking place (Seiso). In order to inculcate such good habit a fixed time was introduced whereby all employees are required to do cleaning of their workplace (Seiketsu). This is seen not only in the shop-floor but also in the office. Triggering of this cleaning activity is by using a standard song (this song was custom made by the company of the survey site) and once it was played at the specified time all staffs automatically starts their cleaning activity (this activity continues for as long as the song plays on – for 5 minutes). By doing so on a daily basis the habit was inculcated (Shitsuke).

From the interview the researcher could pick up quite a number of interesting comments pertaining to how 5S affect the internal supply chain performance. Some common ones are:

"Searching time have reduced as things are now in its place, instead of having to waste time looking for it"

"One good practice we have here is the daily 5 minutes allocated for 5S in our workplace. In these 5 minutes everyone from top management to shop-floor

operators would stop work and do 5S in their workplace. This is good culture and allows for official time off to make sure workplace is in good order"

"By constantly removing unwanted items from the workplace we avoid cluttering. This is important in eliminating the waste of searching time. Furthermore it free up space for more useful functions"

4.3.4. Does the Use of Visual Management have a Significant Effect on Employees' Perception of Internal Supply Chain Performance?

Visual Management – much related to 5S the practice of visual management is concerned with ensuring visibility. When there is a problem it must be quickly and easily seen by all parties.

From the result of the survey done it was seen that there is a significant difference in the perception on internal supply chain performance for those who are having a high exposure to lean practices compared to those who have low exposure. This result agrees with studies done in other industries such as automotive where the use of visual management is very evident (Ranky, 2007). The result concurs with the view by other research which points to the fundamental of using Visual Management so as to highlight issues or problems. This was illustrated by using what was called the "Japanese sea" model (Yamamoto & Bellgran, 2010). Through interviews and observation the researcher was able to witness some interesting cases.

i. Andon Light. Though it is a standard for all machines nowadays to have this andon light (signal tower to inform operator the status of a machine), the

machines are layout in such a way that these lights are easily seen. Managers attest to the fact that by just glancing at the tower lights they could have a quick overview of the production lines situation. Even visitors use to comment on the machine status especially when they see a large percentage of red signal lights (which indicates machine trouble).

ii. Boards displaying Key Performance Indicators (KPI) are placed at strategic locations. These serve to inform the shop-floor and management staff the performance of that particular area. Based on these the managers could quickly probe problem areas when they make their rounds in the production floor. There are some KPI which are static (updated once a day), while for more critical ones the real time KPI is being displayed at strategic locations (using Liquid Chrystal Display (LCD) monitors). These displays are designed to prompt easily. For example if the status is negative against plan red font is used. It is not difficult to assess the situation by having a feel of the number of red fonts compared to green. Appendix 12 shows the examples of how KPIs are displayed. It is a tool that enables fast responds. Even in case of a customer complaint the message is displayed on the screen and the information quickly disseminates down. Such an example agrees with the findings by Kocakulah *et al.* (2011) where they described how the case study site benefit from visual displays, especially when used to monitor quality levels (it is able to share information quickly with the people who need it so that defects are identified and the flow is not disturbed) and production achievement (production control board which displays output versus targets shows where problem area is in real time).

iii. Much linked to visual management is the power of Information and Communication Technology (ICT). As mentioned about the KPIs display on screen, these are made possible via the power of ICT. Visual management is enhanced by extensive use of ICT. Though in the lean practice emphasis is placed on manually displaying data this process of manually displaying has been enhanced through easy access to information through ICT (example in the past the supervisor have to calculate before being able to display, whereas now the supervisor just need to click on to the computer to get the necessary data for display). Furthermore use of ICT also enables real time information to be disseminated. This allows for fast actions on the shop-floor as they respond accordingly to the information.

iv. Use of Kanban or Card system to pull in the required material is also evident in the site. This is a form of non-verbal information flow (Mortimer,2008) and it compliment the internal supply chain performance. By calculating the correct number cards required, the production line could control their inventory. Appendix 13 shows examples of Kanban used.

v. One of the issues faced in the production line for a long time was the inability to ensure First in First out (FIFO) at some processes. This is due to the nature of the containers and storage design. Nevertheless for the area implementing lean, unique ideas using visual control such as in Appendix 14 allows the operators to perform this task in a simple way. Main emphasis is to make things visible.

vi. Another aspect of improving visibility is the practice of removing partitions. By doing so not only are there benefits in term of space free up, but also that it help in exposing what is stored (example in the Appendix 15). When partitions are removed much waste such as walking are reduced (which people take for granted) as the person concerned can now use the shorter route instead of being restricted by the location of doors. Another aspect is the improvement in communication as members are now able to face each other in person rather than face each other separated by a partition. Comments as below were brought up during the interviews:

"Last time when there is a partition separating my process from my previous process, I communicate with my colleagues through the intercom or telephone. However now without the partition I can easily speak to him and we seldom have miscommunication compared to previous"

"As a manager I find that without the partitions things are exposed rather than hidden. This help in making situation clear and will prompt us to take appropriate actions"

"Walking distance has definitely being reduced with no physical partition blocking my path, it is great"

4.3.5. Does Teams have a Significant Effect on Employees' Perception of Internal Supply Chain Performance?

Though the whole population of the site surveyed practice teams in the organization, there is a significant difference in the perception of those who are having a

high exposure to lean practices compared to those who are having a low exposure. Basically the respondents with high exposure to lean practices perceived the effect of teams on a more positive note in term of the effect on internal supply chain performance compared to those with low exposure. Research has shown the positive effect of teams such as improvement in productivity (Fullerton & Wempe, 2009), communication (Bhupathiraju 2008) and generation ideas (Hashim, 2005; Duhe, 2008). Teams encourage participation in improvements through systems for workers suggestions (Olivella *et al.*, 2008). This study concurs with such views and though difficult to generalize it shows that employees in teams with high exposure to lean practices are even more positively inclined in their perception of the effect of teams on internal supply chain performance compared to those with low exposure.

Through the interviews and observation of the case study site,

i. Teams' communication can be seen to improve as the groups are moved from a job shop to a flow shop set-up. In the LFPAK case, operators moved from doing a mono-job to a multi-skill job and this results in better communication as the number of persons involved in the communication flow reduces. Furthermore the communication channel where members speak face to face rather than through a "barrier" such as a partition (whereby a phone or intercom need to be used) enhance communication (Robbins, 2001).

ii. Formation of cross functional teams in the organization also helps in improving many aspect of the operation through problem solving. One evident activity is the SMED (Single Minute Exchange of Die) programme where cross function teams were formed to study and improve changeover

time (of product, machine or dies). With this activity the typical time to changeover from one product type to another was reduced by more than 50% thus making it possible to meet customer order on time through frequent conversions. Due to the fact that time taken is short the capacity of the machine was maintained. In fact the whole exercise in the long run would enable a smaller lot size to be introduced. Once lot size reduce the flow of product becomes even faster, inventory will further reduce (Potoradi, Winz & Kam, 1999). Appendix 8 provides insight into this programme.

iii. Small group activity named "Kaizen Innovative Team" (KIT) was established in the organization with aim of engaging shop-floor members in providing bottom up suggestions and working towards solving specific problems as a team. This successful activity also provides a good avenue for lean practices to be taught. Appendix 16 shows details of this programme.

Some comments received in this dimension are :

"Cross-functional teams are common in this place. Example we have the SMED (Single Minute Exchange of Die) activity where the groups consist of operator, supervisor, technicians and engineers. Changeover time has improved significantly in many cases and this helps us to be more flexible"

"Operators have the opportunity to work in groups through the Kaizen Innovative Team activity. These are teams formed at shop-floor level ranging from 6 to 10

members per group. Their task is to discuss ways to improve their workplace issues such as quality problems, productivity problems, safety etc"

"The suggestion scheme in this Kaizen Innovative Team activity allows for the shop-floor members to make practical proposals on how the workplace could be improved. The groups make proposals on topics such as how to improve the TAT, Improve Changeover time so that there can be more conversions to meet customer requests, overcoming difficulties as a result of new specifications requirement etc"

4.3.6 Does Lean Organizational Structure Practiced have a Significant Effect on Employees' Perception of Internal Supply Chain Performance?

It cannot be denied that organization structure influence the performance of an organization (Inocencia & Jose, 2011). With lean implementation changes in organizational structure slowly but surely evolve. Organizations become flatter as described by Patrickson (1994) and Worley (2004). By a flatter organization it is expected that communication flow would improve in term of accuracy and speed (Heizer & Render, 2001; Alavi, 2003; Olivella *et al.*, 2008). The result of the survey shows that those with high exposure to lean practices have a higher mean in terms of their perception on internal supply chain performance compared to those with low exposure. The difference is significant. From interviews and observations some points are worth mentioning.

i. In the "LSPS Lean Project" the production supervisor's organizational structure was changed from having multiple members to only a single person handling the whole End of Line process. This change according to the manager is an

important step towards improving the communication of the line. Cases of communication breakdown drastically improve as can be seen by the number of communication related issues highlighted.

ii. Engineers observed that with a lean organizational structure, changes in specifications, new products introduction, capacity adjustment could all be carried out more effectively and efficiently.

iii. It was pointed out by some interviewed that having a flatter organizational structure though in general is good, has its setback. For the case of the person having to handle multiple processes it would mean more learning is required. As such a new employee may have difficulty in "skilling" up within a short period of time and this may have a negative consequence in the operation.

From the interview some comments are:

"In a few cases the vertical organization structure (instead of horizontal) improves the flow of information. It also helps in execution of changes requested"

"When the resignation level is high we have difficulty in replacing the person who resigned if her scope in terms of the number of processes is many"

4.3.7 Is there a Significant Correlation between Lean Practices and Internal Supply Chain Performance?

Based on the result of the Pearson Correlation between Lean Practices and Internal Supply Chain Performance there is a strong correlation between these two variables.

One of the important results from the analysis of this study is that there is a strong evidence that the implementation of lean practices have a significant effect on the internal supply chain performance. This adds on to the body of knowledge of yet another case showing the positive aspect of lean implementation.

4.3.8 Is there a Significant Difference in Employees' Perception of Internal Supply Chain Performance in Terms of Gender, Job Function, Age, Length of Service, Sections, Race and Level of Education

From the standpoint of gender, job function, length of service, race and educational level the result shows that there is no significant difference in the perception of internal supply chain performance. Nevertheless, from the aspect of the section they work in there is a significant difference. In fact those in Section 1 shows a higher mean compared to those in Section 2. Section 1 is one area where the management has thus far focused their lean implementation while Section 2 will be in the pipeline pending a review of how well the former has been doing.

It can thus be said that the perception of the employees' of the internal supply chain performance is influenced by which section they work in and not by other demographic characteristics such as gender, job function, age, length of service, race and educational level.

4.4 Summary

The result shows that employees working in an environment where they have a high exposure to lean practices compared to those with low exposure tend to have a more positive perception on how the practices affect the internal supply chain performance. Though not all practices are perceived equally in its influence on internal supply chain performance, the general practices mentioned in this study such as Cellular Layout, 5S, Visual Management and Lean Organizational Structure appear to have a significant difference in influencing the perception of those working there. Apart from the section where they work in, the perceptions obtained were found to be not significant with regard to their demographics characteristics such as gender, job function, age, length of service, race and educational level. The next chapter will discuss on the implication of the results obtained and how it could contribute towards this subject in the short run as well as in the long run.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Study

In this study the case study site was used to measure the perception of employees working in an environment where exposure to lean practices were categorized as either high or low as defined in the operational definition. The last chapter dwell in detail the findings based on the quantitative data as well as the comments from respondents.

A total of 13 hypotheses (inclusive of the sub-hypotheses) were proposed and tested based on the empirical data collected from 186 respondents in a case study site in Penang, Malaysia. This case study site is a Japanese multi-national corporation producing a wide range of semiconductors for export world-wide.

Out of the 13 hypotheses, 5 were found to be not significant while 8 were significant. As a whole based it was found that there is a strong correlation between Lean Practices and Internals Supply Chain Performance. There is a significant difference in the perception of the respondents from those having a high exposure to lean practices compared to those with a low exposure.

5.2 Limitation of the Study

The empirical analysis relies on the single survey of a case study site in a semi-conductor industry. As for the result of this study it cannot be assumed to apply to specific industries or specific firms. Neither can it be representative of multi-national corporations operating in Malaysia. The results can only indicate how respondents in

the said organization perceive the internal supply chain performance within the context of the company. It is contingent upon the environment at that point of time in the organization, thus making generalization nearly impossible.

This study is further limited by the number of lean practices chosen as dimensions to see how it affects the internal supply chain performance. There are many more lean practices which in the context of the case study site is either not practiced or not prominently practiced. Another limitation of this study is that generalization for a particular industry is not feasible. This is because the survey carried out was limited to the scope of a single organization or case (Yin, 2003).

The subjective internal supply chain performance measured (perception) is by itself a limitation. Due to the anonymity of respondents to the survey, it is difficult for the researcher to find objective performance data to supplement the subjective measures (though there were some useful and relevant performance data obtained through interviews and observations as described earlier on). Further limitation of the study pertains to the fact that the empirical data obtained is based on a snapshot rather than a longitudinal data.

Having known the limitations of this study, the researcher still pursued the study as it is as he took into consideration the limited resources available as well as the capability of undertaking the study (Saunders *et al.*,2003).

5.3 Future Direction of the Study

Based on the limitation mentioned, future research could adopt a different strategy to include objective performance measures. This would require a longitudinal data

collection whereby the progress of lean practice implementation could be measured within a time frame planned and the objective performance measured along the way. The data obtained could then be compared to a control section whereby the same objective performance would be measured. Nevertheless this study did quote many cases showing the impact of lean implementation in the site.

Future research can use multiple firms for its survey in order to improve on its generalization. It could concentrate on one particular industry and in the longer term study across industries. With such studies it would expand the scope of those who would want to consider lean practices in their organization.

As the current study focus only on the internal supply chain a future research should expand the scope to external supply chain as well. This is because as the world becomes more globalized the total supply chain (internal and external) becomes more and more important. The study has provided a framework for future research where the lean practices would cover many other practices (Shah & Ward, 2003)

As such the data compiled and analyzed in this research could provide a pool of information for future studies as mentioned above. Some specific examples of possible future studies are,

a) More Japanese Multi-National Corporation

b) Other Non-Japanese Multi-National Corporation

c) Non Semi-Conductor Industry

d) Other Semi-conductor producers in Penang

e) Other Semi-conductor producers in Malaysia

Of course the possibilities are almost endless, but the decision of which direction to take should take into consideration the impact it has in the real business world. For one since the Semi-Conductor industry is so prominent and huge in its contribution to multi-nationals corporation (as in Table 1.1) as well countries there is indeed much wisdom to probe further so that the added knowledge would help enhance not only the academic world, but also the business world at large.

5.4 Contribution of the Study

What this research has done is it adds on to the current body of knowledge pertaining to the subject of internal supply chain performance. With this limited research another case of how lean practices affect the internal supply chain performance is documented and this will benefit the academics as well as the practitioners.

5.4.1 Academic Contributions

a. This study adds on to the existing literatures by examining the perceived effect of internal supply chain performance in a lean implementation. Specifically, it examines the perceived effect of internal supply chain performance (supply chain flexibility, supply chain integration and customer responsiveness) as a result of implementing lean practices (focusing on the dimension of cellular layout, 5S, Visual Management, Teams and Organizational Structure).

b. There are several unique and significant contributions to the body of knowledge. First, the effect of lean practices on the perceived effect of internal supply chain performance was measured in a case study site covering a rather big population (with

respondents from different job functions inside the organization). Prior research as detailed in the literature review uses a data sets that are wider in scope with respect to the number of sites (such as by Qrunfleh (2010) where the survey was based only on key personnel from a wide range of organizations, industries etc). The views are from the few key personnel such as CEO, Directors and managers. Actual perceptions from those who are working at shop-floor are not captured. There is no known analysis of this type conducted in a single population as in this research.

c. A framework linking the lean practices to internal supply chain performance was developed. It provides empirical data to show that those with a high exposure to lean practices have a more positive perception on internal supply chain performance.

d. To the body of knowledge this case also reinforce the contingency theory as it shows that the perception of the respondents are contingent upon the environment they work in (whether they have a high exposure to lean practices or otherwise).

e. This research would add on the current literature available and will contribute to future studies to determine if these results are consistent

5.4.2 Practical Contributions

a. For the practitioners it provides insight into how the employees perceive the effect internal supply chain performance as the organization implement lean. As can be observed in interviews the management expectation and the implementer's perception may not tally in all occasions. For instance the management would think that making

layout changes would have a significant impact on the perception of employees as much resource (as lots of money are needed for layout changes) are put into it while other not so dramatic measures such as visual management or 5S may not have much of an impact. The result obtained in the survey showed that all the lean practices does have a significant difference in the perception of the employees' pertaining to internal supply chain performance regardless of whether much finance is channeled into it or not. Effort that looks so much simpler and cheaper such as 5S, Teams and Visual Management provides a significant impact too. As such from the practical aspect in a lean implementation the organization could consider putting in more resources (not necessary money) into these practices so as to benefit from the implementation albeit with less financial cost. Furthermore these so called cheaper ways could help in the employees buying-in to the implementation as it involves activities that they could hands on. With an early buy in the organization could gain substantial benefits within a shorter time frame.

b. Though the research is on the perception of the respondents, the few cases quoted with examples of tangible benefits (such as in Appendix 6) can provide justification of why lean practices is worth considering. It also reinforces the notion that lean practices preached does work.

c. Though the research is on a single site, it provides practitioners who are in the same industry relevant information which may help them in a similar implementation.

d. At the firm level, decision makers can more effectively make a case for a greater share of corporate resources if they are able to provide evidence that the application of particular practices manifest enhanced internal supply chain performance.

5.5 Recommendations

Based on the findings of this study the below recommendations are put forward.

a. With the clear statistically significant difference obtained for the respondents from Section 1 and Section 2 the organization should go forward and implement lean in Section 2 too. It is not only the perception that shows a positive mean in Section 1 but that the tangible benefits such as TAT reduction, WIP Reduction, Productivity improvement, Production Space optimization, Process length reduction, Walking reduction, Waste or muda elimination or reduction etc are evident for all to see.

b. In the event decisions were made to implement lean in Section 2, some transfer of personnel from Section 1 to 2 would help in the assimilation of lean philosophy. This would help in a smoother implementation.

c. Concentrating on key products (based on 80/20 rule, it should be on the vital few products which makes the biggest contribution to sales) during implementation would also be helpful as it provides focus especially in view of limited resource. By doing so the chances of success would be higher and this would spur greater excitement in total implementation.

d. Even though there are many visual controls in place the organization can explore not only visual aid but also audio. Success stories can be found in Kocakulah *et al.* (2011) where the use of audio alarms enhanced their communication system. They achieved this by playing a standard tune whenever they want to inform shop-floor staffs of the detection of a particular defect created.

e. Quantifying the achievements in monetary terms is an important task as it provided justification for further implementation or otherwise. For example the inventory reduction could be quantified not only by the number of days of stock but also in the amount of cash flow improved; the productivity of operators could be calculated by the human time saved which could then be converted to cost based on human cost per hour; machine operating rate improvement could be calculated by the increased production capacity which could be translated into cost of buying extra equipment etc (Horngren, Sundem & Stratton, 2002).

f. In the event that financial resource is limited, the implementation should focus on practices that have significant impact such as 5S, Teams, Visual Management and Lean Organizational Structure. Having said that it did not mean that the organization should totally ignore practices such as cellular layout though in most situations it would require some substantial financial resource. Furthermore the implementers should always be challenged to explore the many other lean practices (Shah & Ward, 2003).

g. As some researchers mention, lean implementation is a mind-set change (Liker & Franz, 2011; Liker, 2004; Womack & Jones, 2005; Hines, Holweg & Rich, 2004). There is a need to obtain the buy in through effective communication. Events such a

having presentation of success stories like the cases mentioned would help encourage those who are involved and challenge those who are yet to be involved. Visible top management support through words and deeds cannot be overstated (Worley & Doolen, 2006).

h. It is a wise thing (within the financial resource of the organization) to engage the service of lean consultants in implementing lean practices in the organization as this could accelerate the rate of implementation. Success stories of organizations doing so with help of consultants can be found in literature (Yamamoto & Bellgran, 2010; Kocakulah *et al.*, 2011). In the case of Kocakulah *et al.* (2011) they initially achieved a degree of success without consultant help but were found lacking in some areas. The review by the consultants later on directed them to implement the mindset of lean thinking and also to incorporate Kaizen workshops and other lean focus events such as Kaizen Blitz (where in 3 weeks a LFE could be carried out where 1st week is observation of work on the shop floor, 2nd week is spent on developing a future work state in which simulation can be carried out and the 3rd week is on implementation of the new standard work).

i. Even though there is always the pressure to quickly carry out horizontal deployment of ideas or changes, managers need to be taught the contingency theory and realize that there is seldom a solution that fits perfectly from one scenario to another. As such it is necessary to make thorough studies in a lean implementation as environment differs from one area to another (Donaldson, 2001; Erik, 2010).

5.6 Conclusion

This study on the effect of lean practices on the perception of internal supply chain performance has contributed in several ways to the existing literature.

a. It identified key lean practices within the scope of a case study site in Malaysia and measured the perception of the respondents within that population.

b. Though lean practices are widely researched, the number of studies in Malaysia is rather few in comparison. As such this adds to the literature on this subject.

c. The methodology of this study is spelled out in quite detail and can be replicated by future researchers so as to add on to the body of knowledge.

d. 13 hypotheses were successfully tested and out of that 5 were found to be not significant.

e. Limitations in this study are also highlighted, explaining why generalization in this situation is rather difficult as the responses are contingent upon the environment of the case study site.

f. The findings highlighted the importance of studying organizational phenomenon within real-world settings (Worley & Doolen, 2006) and to take into consideration the contingency factors as the success of lean practices is

contingent upon the scenario of the site implementing it. This is also what the contingency theory claim.

g. The comment by Yamamoto & Bellgran (2010) in their paper on the fundamental mindset that drives improvements towards lean production is relevant even for this paper. It highlighted the need to "occasionally by force, create a situation where people have no choice (or little choice) but to feel the need of improvement". With this the performance of the organization should improve.

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APPENDIX 1a: COVER LETTER FOR QUESTIONNAIRE

SURVEY ON THE RELATIONSHIP BETWEEN LEAN PRACTICES AND INTERNAL SUPPLY CHAIN PERFORMANCE

Dear Respondents

The intention of this survey is to obtain the perception of the respondents pertaining to the relationship between lean practices and internal supply chain performance in this organization. Your response will help in the understanding of this relationship and will contribute to the body of knowledge. It will be of interest for both practitioners as well as academicians who are keen on pursuing this subject.

INSTRUCTIONS

Please answer all questions in section 1 (A to E) and 2. As for Section 1 please rate the appropriate scale by clicking the boxes. There is no right or wrong answer.
For any clarification please contact Mr Fong Soon Oon (soonoon.fong.ra@rsm.renesas.com) at extension 3590.

APPENDIX 1b: QUESTIONNAIRE

1. Relationship Between Lean Practices and Internal Supply Chain Performance
(Please Click the appropriate boxes)

	A) Use of Cellular Layout enable us to	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1.Handle difficult non standard orders	☐1	☐2	☐3	☐4	☐5
	2. Meet special customer specification	☐1	☐2	☐3	☐4	☐5
	3. Produce products characterized by numerous features such as sizes and colours	☐1	☐2	☐3	☐4	☐5
	4. Rapidly adjust capacity so as to accelerate or decelerate production in response to changes in demand	☐1	☐2	☐3	☐4	☐5
	5. Handle rapid introduction of new products	☐1	☐2	☐3	☐4	☐5
	6. Achieve a high level of communication and coordination between all functions in our organization	☐1	☐2	☐3	☐4	☐5
	7. Promote cross functional teams towards improvement in work place	☐1	☐2	☐3	☐4	☐5
	8. Promote a great amount of cross-over activities within the organization (such as certain jobs now done could be carried out by the next process instead)	☐1	☐2	☐3	☐4	☐5
	9. Achieve a high level of integration of Information System in our organization	☐1	☐2	☐3	☐4	☐5
Customer Responsiveness	10. Meet customer order on time	☐1	☐2	☐3	☐4	☐5
	11. Achieve short order-to-delivery cycle time (Turn Around Time)	☐1	☐2	☐3	☐4	☐5
	12. Achieve fast customer response time	☐1	☐2	☐3	☐4	☐5

	B. Good SS enable us to	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1 Handle difficult non standard orders	☐1	☐2	☐3	☐4	☐5
	2 Meet special customer specification	☐1	☐2	☐3	☐4	☐5
	3 Produce products characterized by numerous features such as sizes and colours	☐1	☐2	☐3	☐4	☐5
	4 Rapidly adjust capacity so as to accelerate or decelerate production in response to changes in demand	☐1	☐2	☐3	☐4	☐5
	5 Handle rapid introduction of new products	☐1	☐2	☐3	☐4	☐5
	6 Achieve a high level of communication and coordination between all functions in our organization	☐1	☐2	☐3	☐4	☐5
	7 Promote cross functional teams towards improvement in work place	☐1	☐2	☐3	☐4	☐5
	8 Promote a great amount of cross-over activities within the organization (such as certain jobs now done could be carried out by the next process instead)	☐1	☐2	☐3	☐4	☐5
	9 Achieve a high level of integration of Information System in our organization	☐1	☐2	☐3	☐4	☐5
Customer Responsiveness	10 Meet customer order on time	☐1	☐2	☐3	☐4	☐5
	11 Achieve short order-to-delivery cycle time (Turn Around Time)	☐1	☐2	☐3	☐4	☐5
	12 Achieve fast customer response time	☐1	☐2	☐3	☐4	☐5

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1 Handle difficult non standard orders	☐1	☐2	☐3	☐4	☐5
	2 Meet special customer specification	☐1	☐2	☐3	☐4	☐5
	3 Produce products characterized by numerous features such as sizes and colours	☐1	☐2	☐3	☐4	☐5
	4 Rapidly adjust capacity so as to accelerate or decelerate production in response to changes in demand	☐1	☐2	☐3	☐4	☐5
	5 Handle rapid introduction of new products	☐1	☐2	☐3	☐4	☐5
	6 Achieve a high level of communication and coordination between all functions in our organization	☐1	☐2	☐3	☐4	☐5
	7 Promote cross functional teams towards improvement in work place	☐1	☐2	☐3	☐4	☐5
	8 Promote a great amount of cross-over activities within the organization (such as certain jobs now done could be carried out by the next process instead)	☐1	☐2	☐3	☐4	☐5
	9 Achieve a high level of integration of Information System in our organization	☐1	☐2	☐3	☐4	☐5
Customer Responsiveness	10 Meet customer order on time	☐1	☐2	☐3	☐4	☐5
	11 Achieve short order-to-delivery cycle time (Turn Around Time)	☐1	☐2	☐3	☐4	☐5
	12 Achieve fast customer response time	☐1	☐2	☐3	☐4	☐5

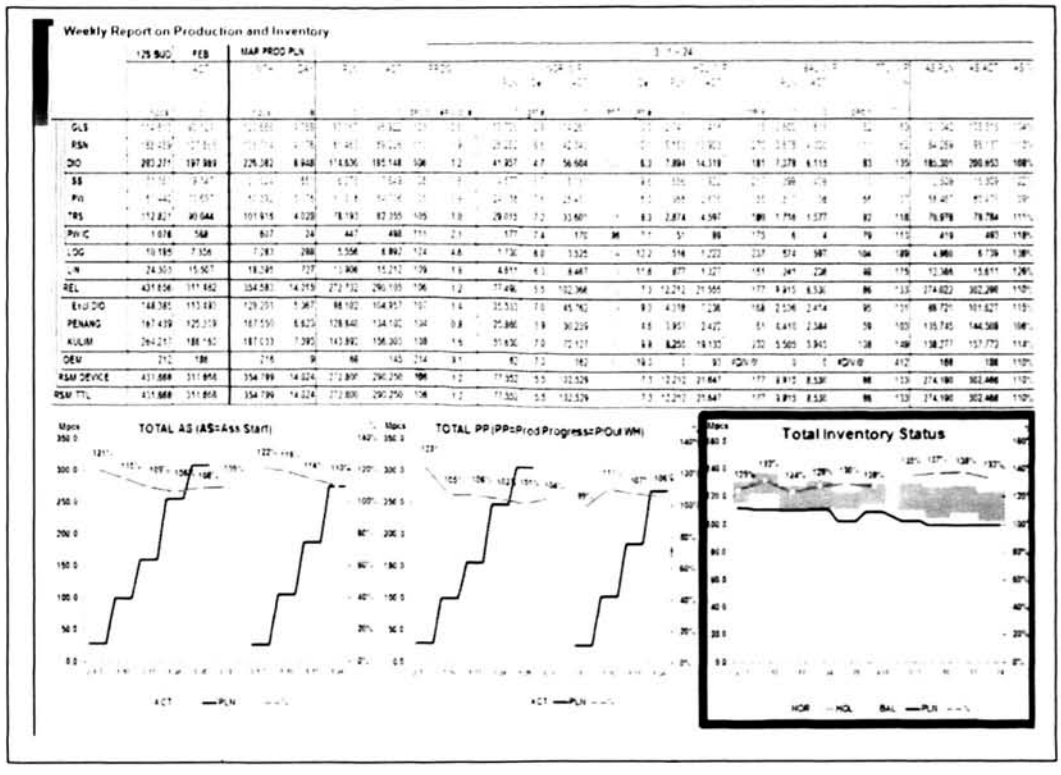
	C) With Visual Management we are able to:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1 Handle difficult non standard orders	☐1	☐2	☐3	☐4	☐5
	2 Meet special customer specification	☐1	☐2	☐3	☐4	☐5
	3 Produce products characterized by numerous features such as sizes and colours	☐1	☐2	☐3	☐4	☐5
	4 Rapidly adjust capacity so as to accelerate or decelerate production in response to changes in demand	☐1	☐2	☐3	☐4	☐5
	5 Handle rapid introduction of new products	☐1	☐2	☐3	☐4	☐5
	6 Achieve a high level of communication and coordination between all functions in our organization	☐1	☐2	☐3	☐4	☐5
	7 Promote cross functional teams towards improvement in work place	☐1	☐2	☐3	☐4	☐5
	8 Promote a great amount of cross-over activities within the organization (such as certain jobs now done could be carried out by the next process instead)	☐1	☐2	☐3	☐4	☐5
	9 Achieve a high level of integration of Information System in our organization	☐1	☐2	☐3	☐4	☐5
Customer Responsiveness	10 Meet customer order on time	☐1	☐2	☐3	☐4	☐5
	11 Achieve short order-to-delivery cycle time (Turn Around Time)	☐1	☐2	☐3	☐4	☐5
	12 Achieve fast customer response time	☐1	☐2	☐3	☐4	☐5

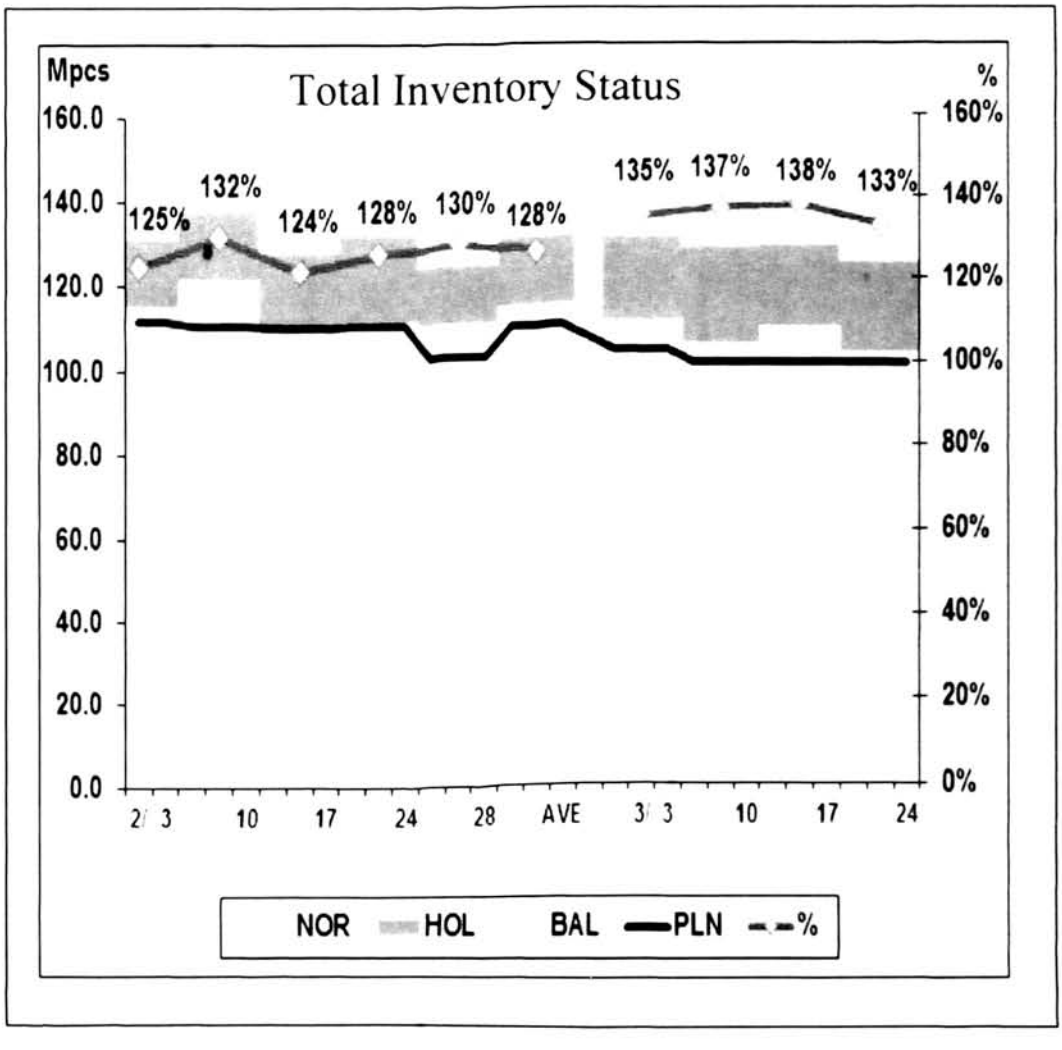
	D: Teams enable us to:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1 Handle difficult non standard orders	☐1	☐2	☐3	☐4	☐5
	2 Meet special customer specification	☐1	☐2	☐3	☐4	☐5
	3 Produce products characterized by numerous features such as sizes and colours	☐1	☐2	☐3	☐4	☐5
	4 Rapidly adjust capacity so as to accelerate or decelerate production in response to changes in demand	☐1	☐2	☐3	☐4	☐5
	5 Handle rapid introduction of new products	☐1	☐2	☐3	☐4	☐5
	6 Achieve a high level of communication and coordination between all functions in our organization	☐1	☐2	☐3	☐4	☐5
	7 Promote cross functional teams towards improvement in work place	☐1	☐2	☐3	☐4	☐5
	8 Promote a great amount of cross-over activities within the organization (such as certain jobs now done could be carried out by the next process instead)	☐1	☐2	☐3	☐4	☐5
	9 Achieve a high level of integration of Information System in our organization	☐1	☐2	☐3	☐4	☐5
Customer Responsiveness	10 Meet customer order on time	☐1	☐2	☐3	☐4	☐5
	11 Achieve short order-to-delivery cycle time (Turn Around Time)	☐1	☐2	☐3	☐4	☐5
	12 Achieve fast customer response time	☐1	☐2	☐3	☐4	☐5

	E) Our Organizational Structure practiced enable us to:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1 Handle difficult non standard orders	☐1	☐2	☐3	☐4	☐5
	2. Meet special customer specification	☐1	☐2	☐3	☐4	☐5
	3. Produce products characterized by numerous features such as sizes and colours	☐1	☐2	☐3	☐4	☐5
	4. Rapidly adjust capacity so as to accelerate or decelerate production in response to changes in demand	☐1	☐2	☐3	☐4	☐5
	5. Handle rapid introduction of new products	☐1	☐2	☐3	☐4	☐5
	6. Achieve a high level of communication and coordination between all functions in our organization	☐1	☐2	☐3	☐4	☐5
	7. Promote cross functional teams towards improvement in work place	☐1	☐2	☐3	☐4	☐5
	8. Promote a great amount of cross-over activities within the organization (such as certain jobs now done could be carried out by the next process instead)	☐1	☐2	☐3	☐4	☐5
	9. Achieve a high level of integration of Information System in our organization	☐1	☐2	☐3	☐4	☐5
Customer Responsiveness	10. Meet customer order on time	☐1	☐2	☐3	☐4	☐5
	11. Achieve short order-to-delivery cycle time (Turn Around Time)	☐1	☐2	☐3	☐4	☐5
	12. Achieve fast customer response time	☐1	☐2	☐3	☐4	☐5

2. General Information (Please Click the appropriate boxes)	
Section	☐1 Section 1 ☐2 Section 2
Process	☐1 FOL ☐2 MOL ☐3 EOL ☐4 Overall
Job Function	☐1 Operation ☐2 Engineering ☐3 Management
Education Level	☐1 High School/Diploma/ Certificate ☐2 Tertiary Degree (Bachelor Master Doctoral)
Age Range (Years)	☐1 < 20 ☐2 21~30 ☐3 31~40 ☐4 > 41
Years in Service (Years)	☐1 < 2 ☐2 2 ~ 5 ☐3 6 ~ 10 ☐4 > 10
Gender	☐1 Male ☐2 Female
Race	☐1 Malay ☐2 Chinese ☐3 Indian ☐4 Others

APPENDIX 2: Weekly Report showing inventory level





APPENDIX 3: LSPS LEAN PROJECT

LSPS LEAN PROJECT

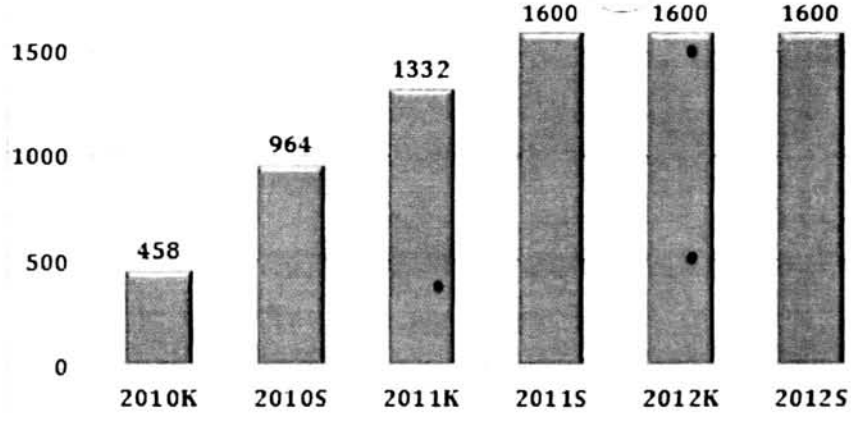
To reduce the Turn-Around-Time of Linear LSPS to 160hours/lot (2Kc) By July/2012.

(PJ Launch: 11-Jan-2012)

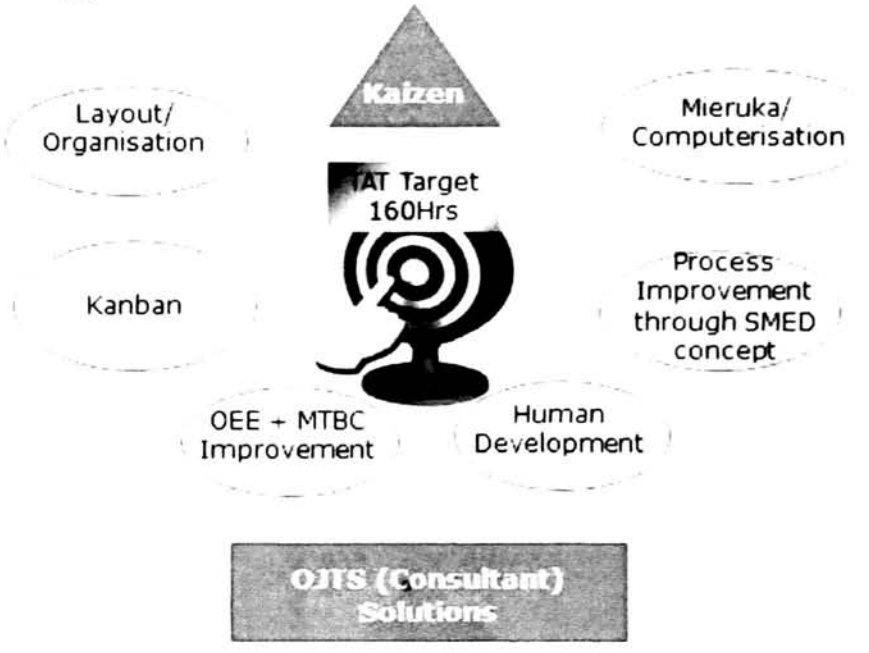
2) LSPS Production

Key Product for RSM Linear Production Department

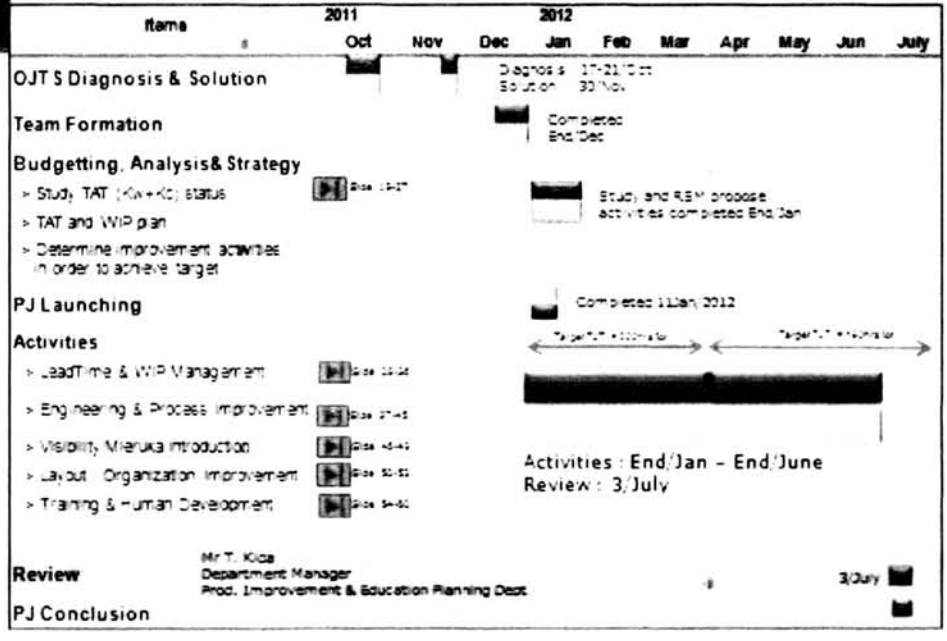
Item (2011S)	LSPS/Total	LSPS %
Qty	1.6 / 12.8 Mpcs	12%
Sales	13.8 / 38.6 MRM	36%
WorkHrs	27.9 / 88.2 hours	32%



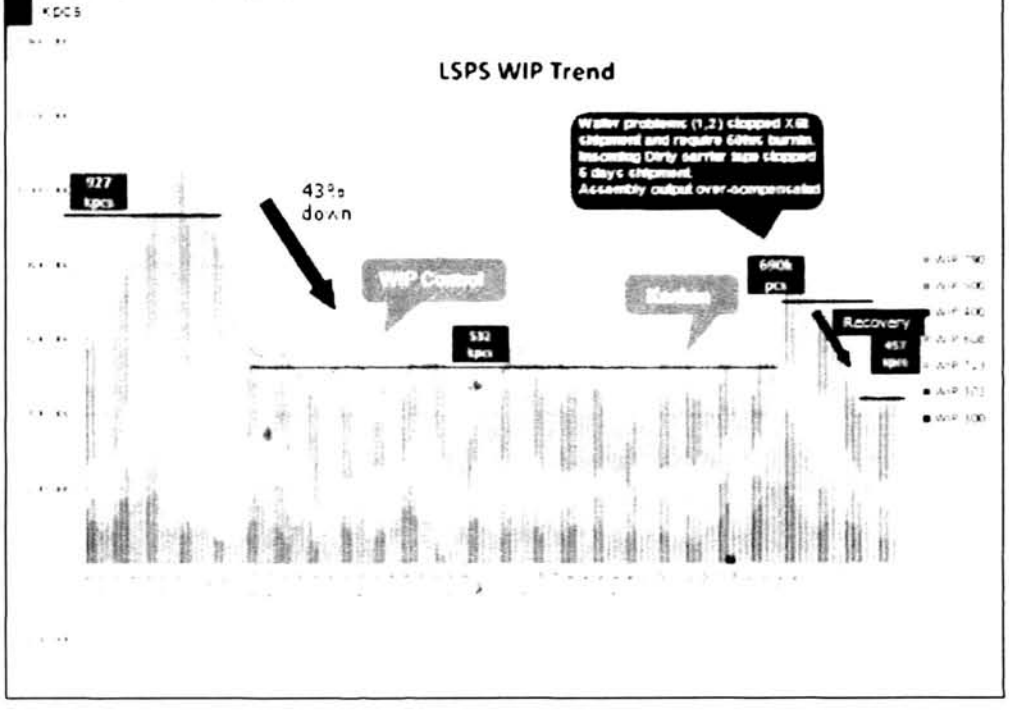
Strategy



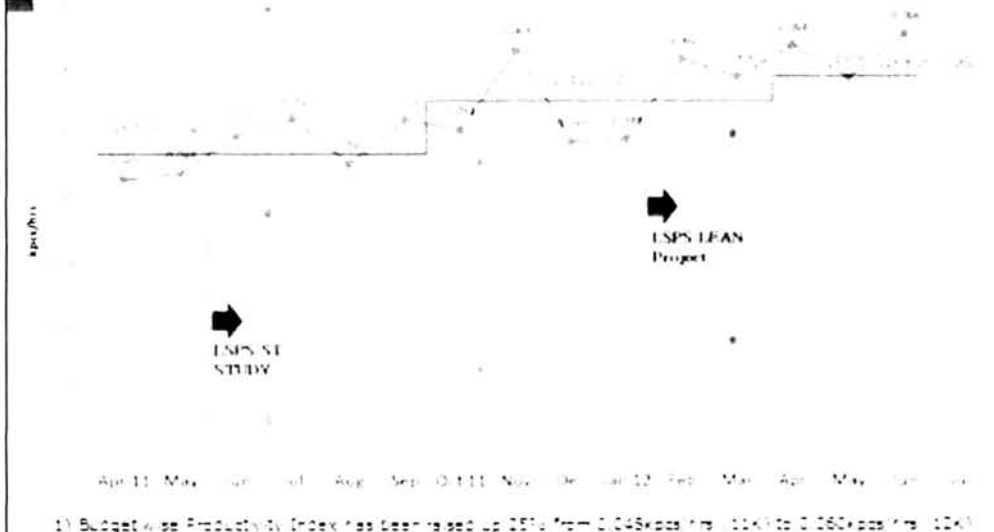
Linear LSPS Lean Manufacturing PJ Schedule



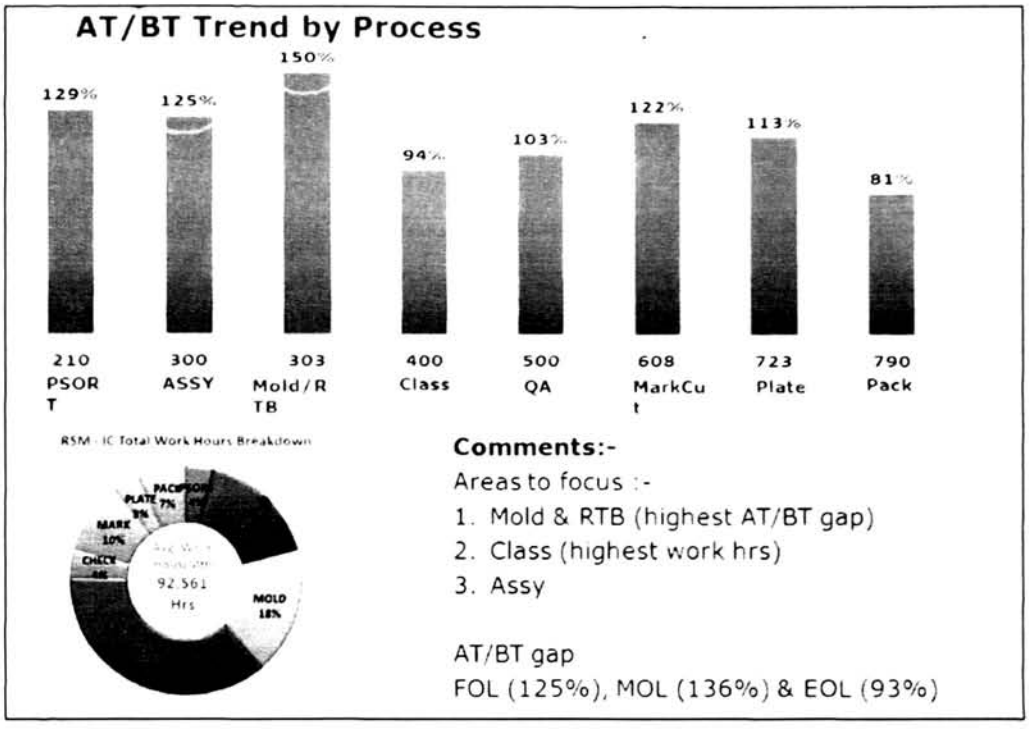
LSPS WIP Trend

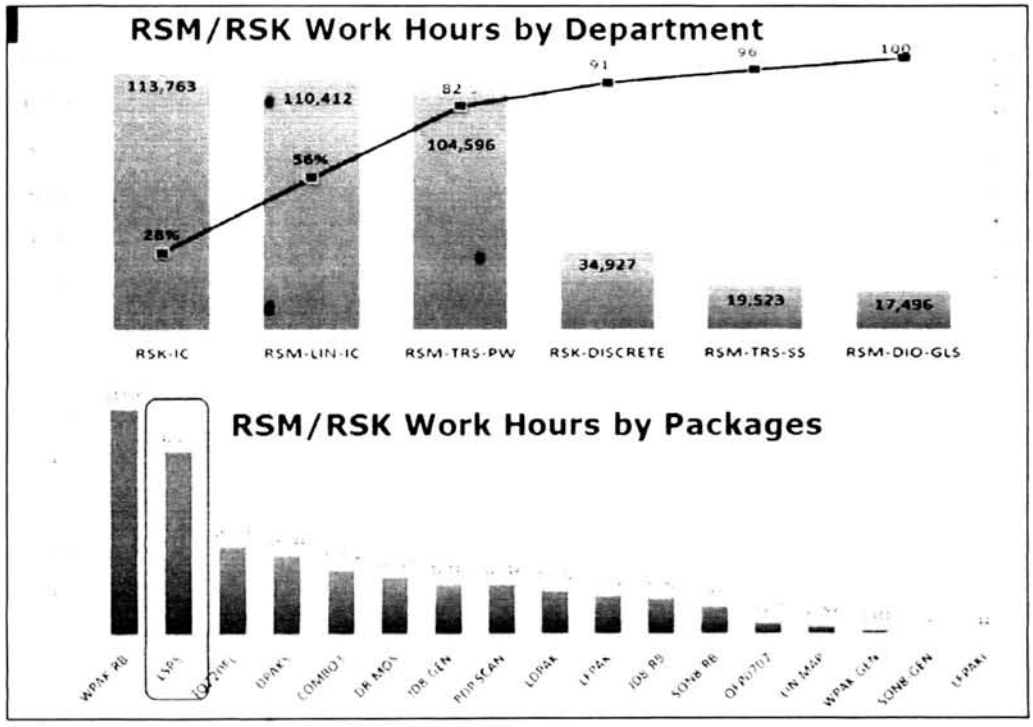


LSPS Productivity Index (kpcs/hr)



1) Budget wise Productivity Index has been raised up 25% from 0.048kpcs/hr (12K) to 0.060kpcs/hr (12K) (BT also improve by 25%). LSPS Lean P3 enable LSPS to achieve 12K Bud 0.060kpcs/hr

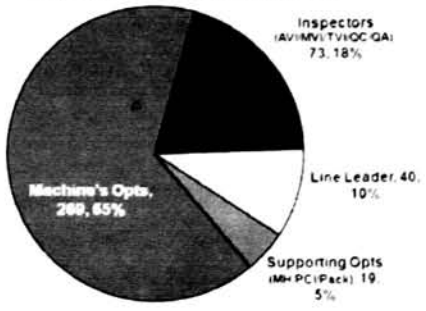

AT/BT Trend by Process
129%
125%
150%
94%
103%
122%
113%
81%
210 PSORT
300 ASSY
303 Mold/RTB
400 Class
500 QA
608 MarkCut
723 Plate
790 Pack
RSM - IC Total Work Hours Breakdown
92,561 Hrs
MOLD 18%
MARK 10%
PLATE 7%
Comments:-
Areas to focus :-
1. Mold & RTB (highest AT/BT gap)
2. Class (highest work hrs)
3. Assy
AT/BT gap
FOL (125%), MOL (136%) & EOL (93%)


RSM/RSK Work Hours by Department
113,763
110,412
104,596
34,927
19,523
17,496
28%
58%
82
91
96
100
RSK-IC
RSM-LIN-IC
RSM-TRS-PW
RSK-DISCRETE
RSM-TRS-SS
RSM-DIO-GLS
RSM/RSK Work Hours by Packages

Manpower Allocation

No	Process	Job Function	No of Opts (3 shifts)
1	PSORT		7
			2
			2
		Total PSORT	11
2	ASSY		41
			6
			8
		Total PSORT	65
3	MOLD & RTB		48
			5
			20
			3
		Total MOL	76
4	MTP		35
			4
			3
			1
		Total MOL	43
5	CLASS		100
			9
			2
		Total MOL	111
6	FVI		26
			4
			3
		Total MOL	33
7	TAPE & PACK		28
			6
			6
		Total EOL	40
8	QC		12
			13
			1
		Total QC	16
	QA		13
			3
		Total QA	16
			12
		Total	411

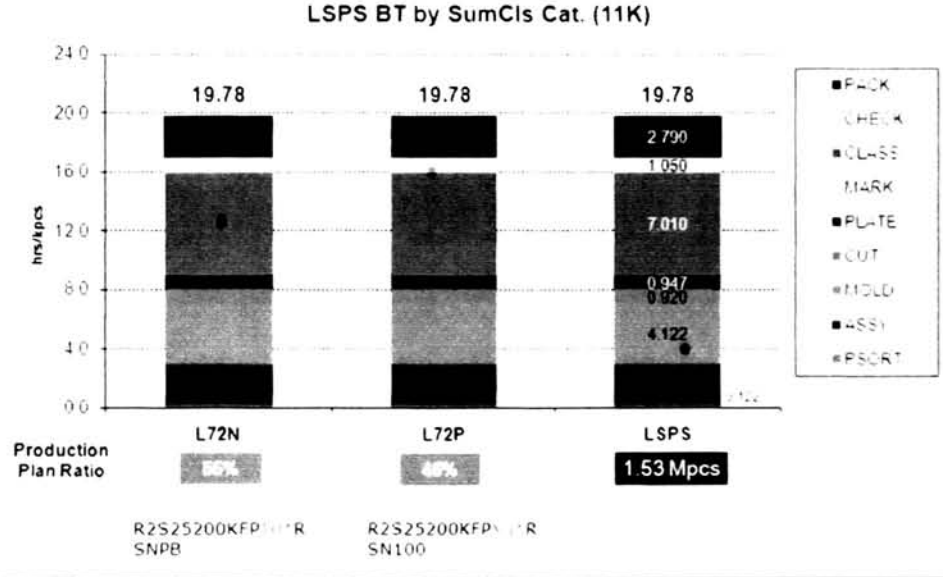
Operators Breakdown

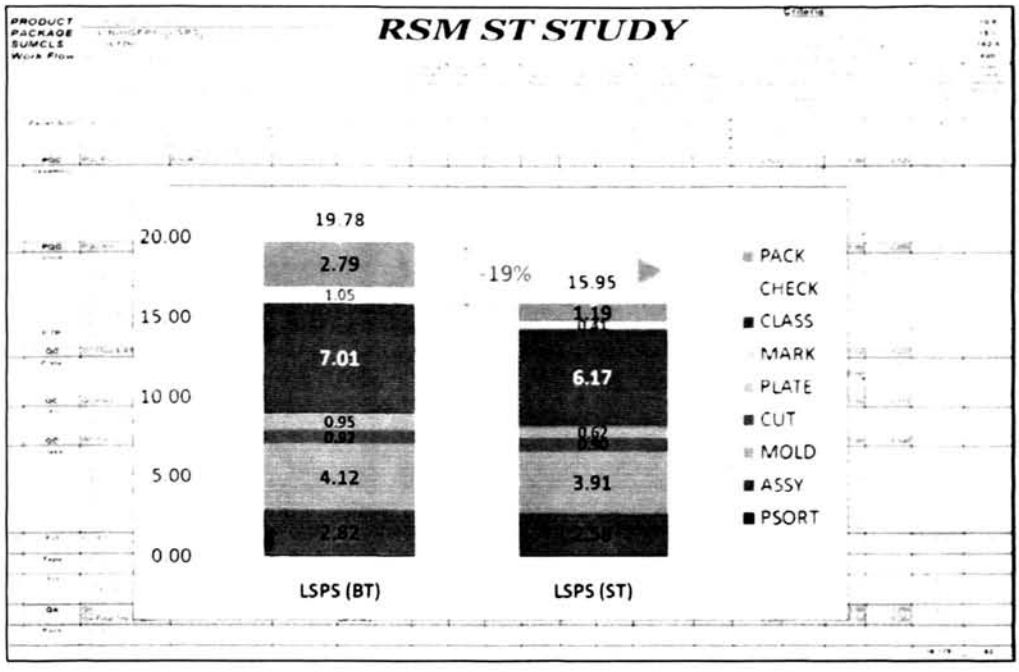


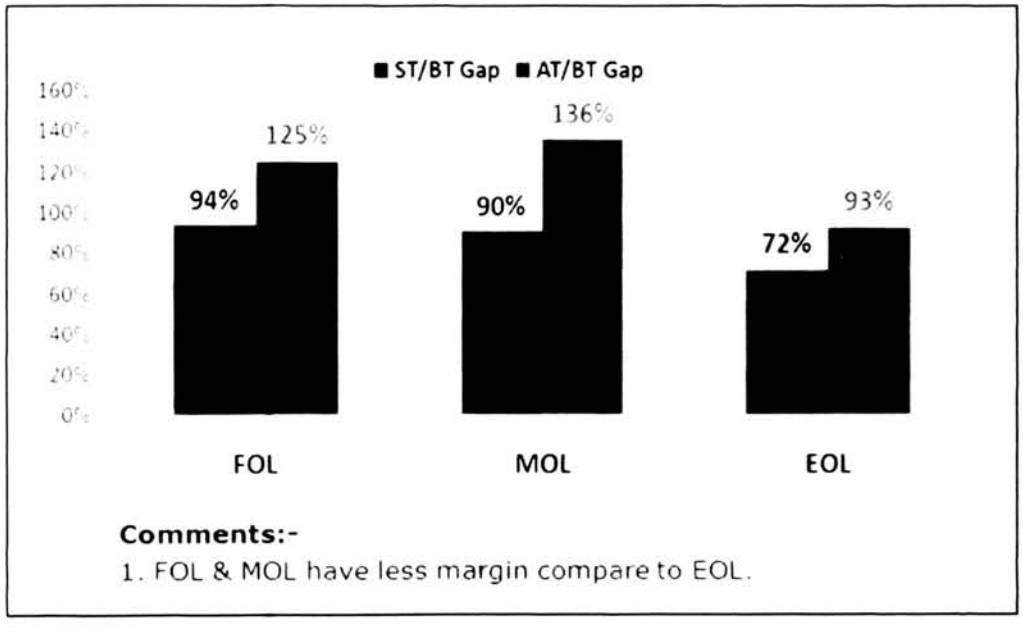
Comments:-

1. Class has highest no of operators, follow by Mold/RTB & Assy.

LSPS Budget Time (11K)

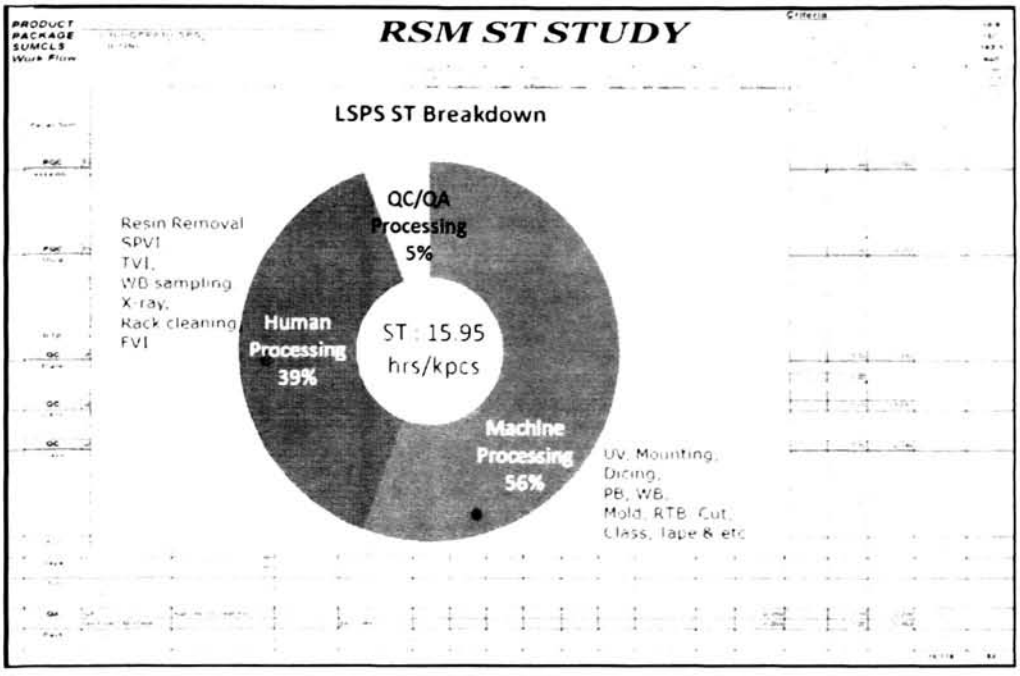


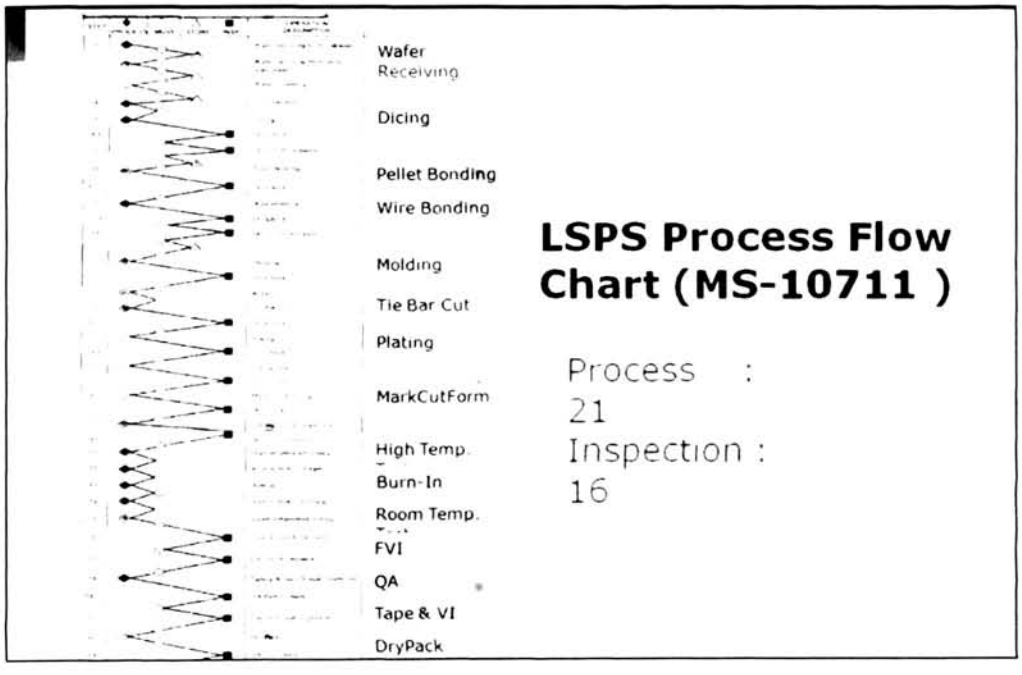


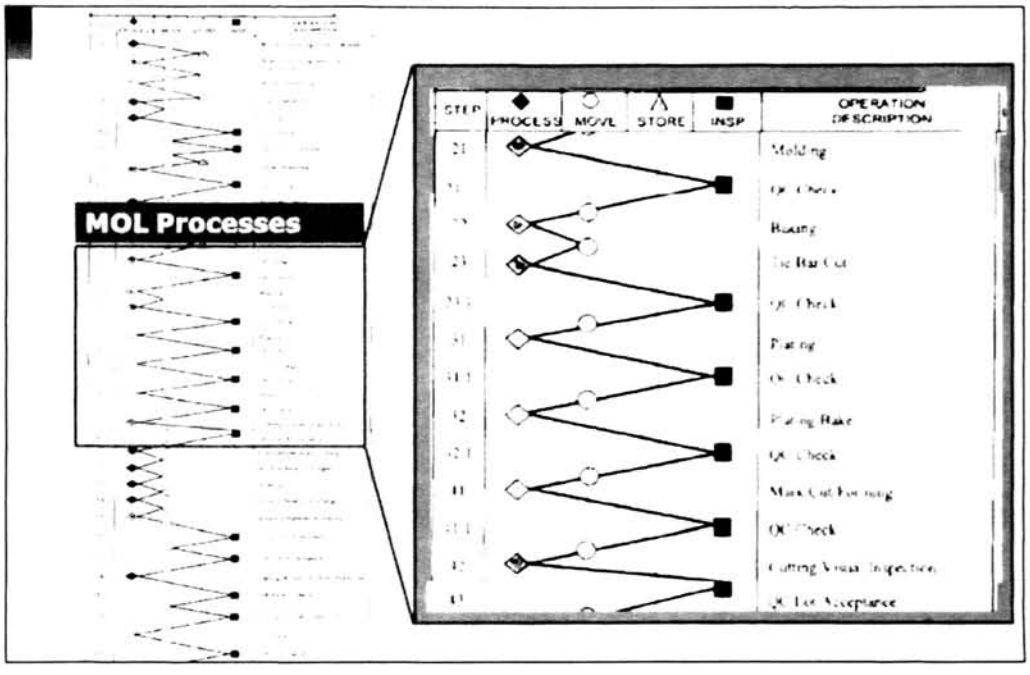


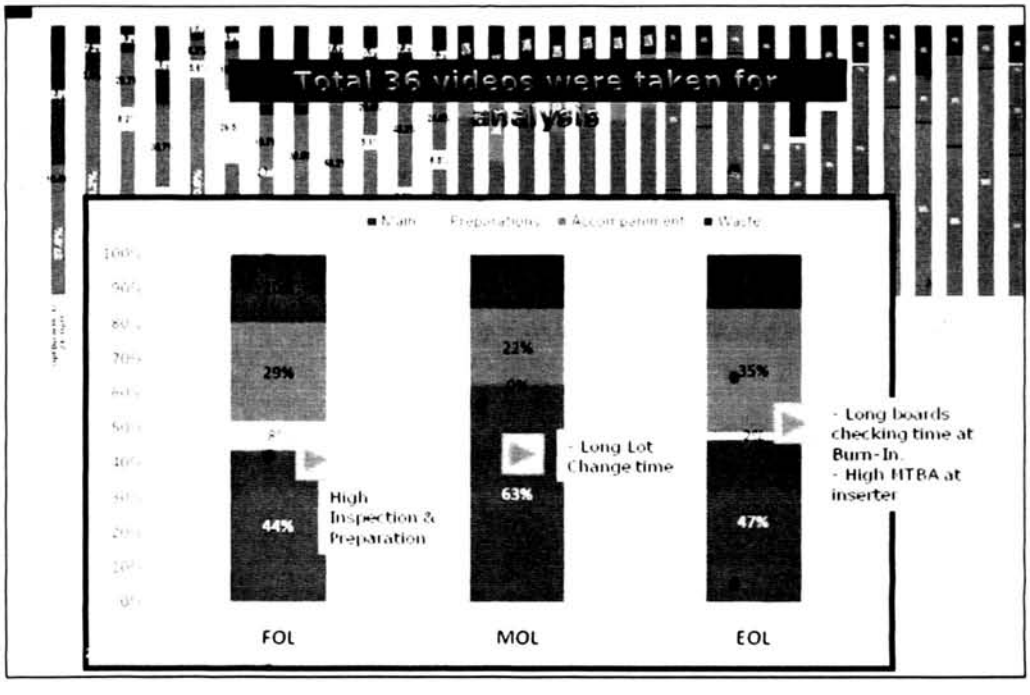
Comments:-

1. FOL & MOL have less margin compare to EOL.


RSM ST STUDY
LSPS ST Breakdown
QC/QA Processing 5%
Resin Removal
SPVI
TVI,
WB sampling
X-ray,
Rack cleaning
FVI
Human Processing 39%
ST : 15.95 hrs/kpcs
Machine Processing 56%
UV, Mounting,
Dicing,
PB, WB,
Mold, RTB Cut,
Class, Tape & etc


Wafer Receiving
Dicing
Pellet Bonding
Wire Bonding
Molding
Tie Bar Cut
Plating
MarkCutForm
High Temp.
Burn-In
Room Temp.
FVI
QA
Tape & VI
DryPack
LSPS Process Flow Chart (MS-10711)
Process : 21
Inspection : 16

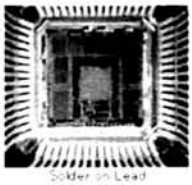

MOL Processes
STEP
PROCESS
MOVE
STORE
INSP
OPERATION DESCRIPTION


Total 36 videos were taken for
analysis
Main
Preparation
Accompaniment
Waste
29%
44%
High Inspection & Preparation
22%
63%
- Long Lot Change time
35%
47%
- Long boards checking time at Burn-In.
- High HTBA at inserter
FOL
MOL
EOL

Pellet Bond Operation

Detail explanation by working group leader.

Product Check : 49% of operator



L/F	L/F #	Usage	Sample	Time Taken	MMR
Mitsui	L003149T	70%	100%	47.0 min /	
Hitachi	L50649	30%	10%	7.5 min /	1 : 2

PB Processing Time : 93

MMR : 1 opt : 1 m/cs

Due to different base material of the frame & causing solder can not stick on the frame & splashing issues.

Operator spent time on this activities : (47 / 93) min

Pellet Bond Operation

Preparation : 14% of Operators time (L/F unpack & loading)

L/F	L/F #	L/F Qty/	Prep. Time	Opt Time /
Mitsui	L003149T	30 F / bundle	0.8s / F	3.7 min / Lot
Hitachi	L50649	8 F / bundle	1.5s / F	7 min / Lot

PB Processing Time : 93

MMR : 1 opt : 2 m/cs

Operator spent time on this activities : (7*2 / 93) min

Work Sampling (WB)

Detail explanation by working group leader.

Send sample to sampling operator

Comments:-

1. Very frequent operators have to look for sampling operators for confirmation. This is due to every change of materials; wire, capillary & type, products need to be confirm.
2. Machine has to stop & only start after PQC confirmation.

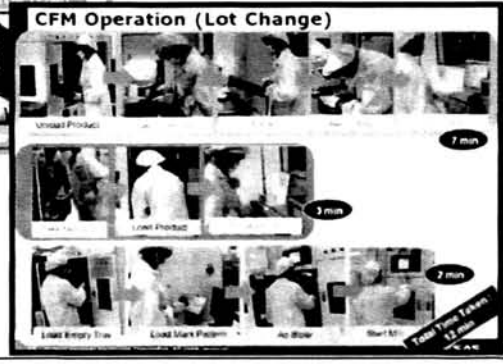
Work Sampling (MOL)

RTB Operation (Lot Change)

Lot Change Activities

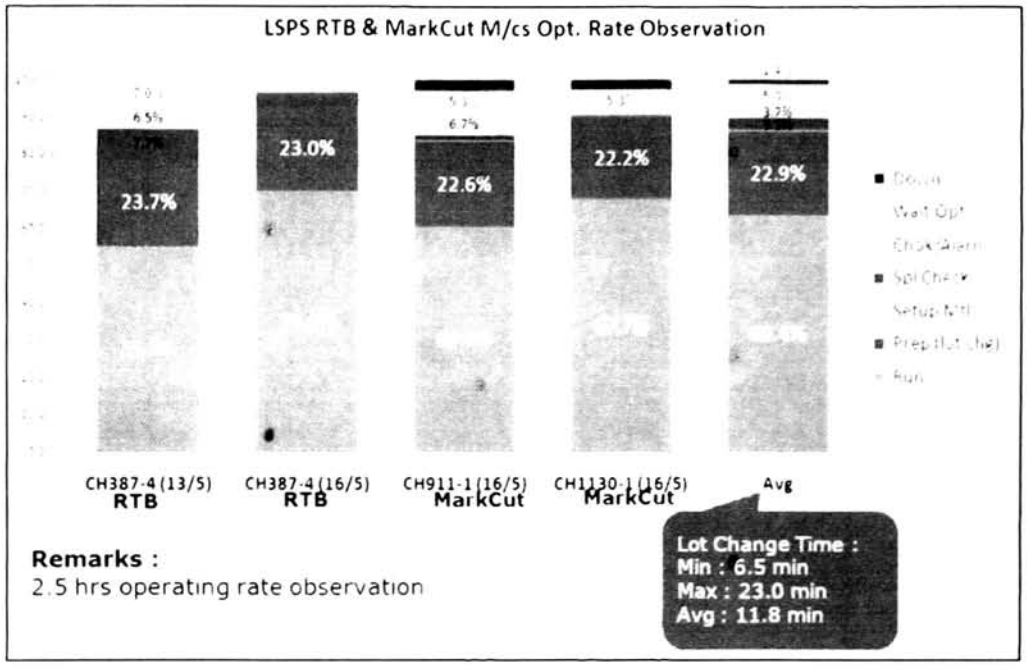
1.Load & Unload
2.Inspection & Sampling Checks
3.Counting of qty.
4.Recording.
5.PC data entry (move In & out)
6. Products transfer.

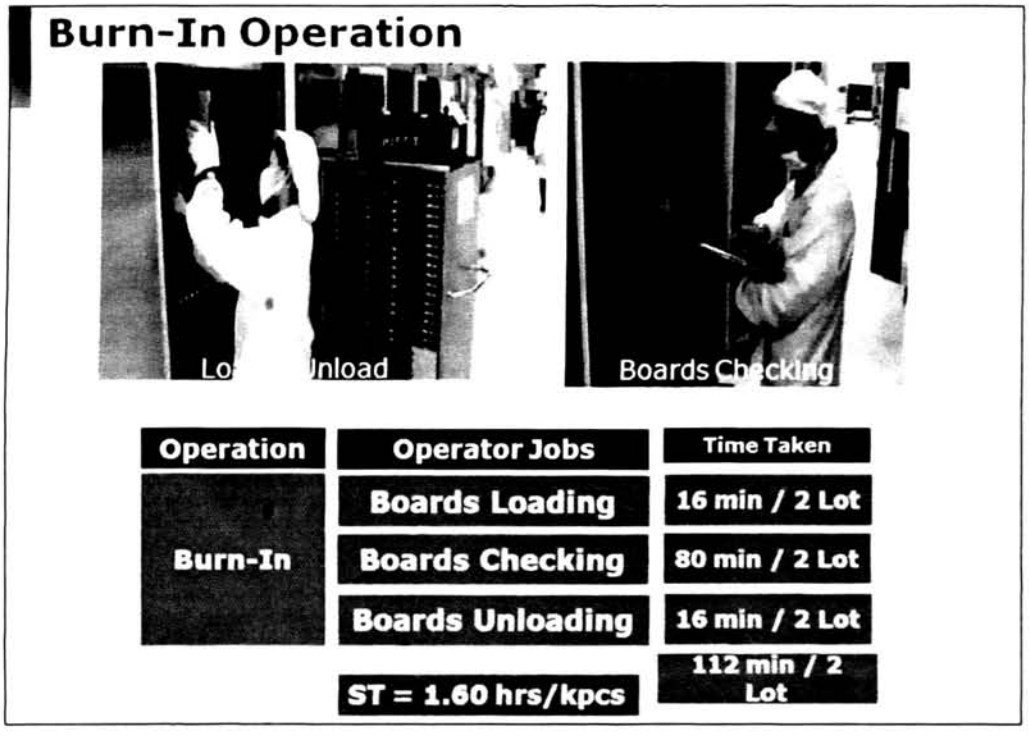
CFM Operation (Lot Change)



Comments:-

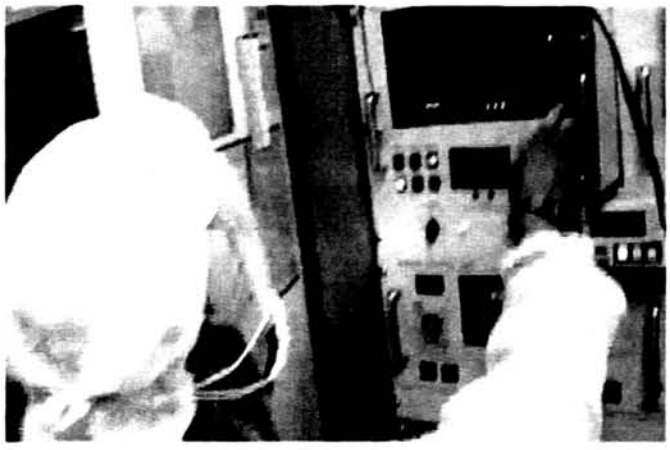
1. Long lot change time (@12min).
2. Not standardize procedures.


LSPS RTB & MarkCut M/cs Opt. Rate Observation
6.5%
23.7%
23.0%
6.7%
22.6%
22.2%
22.9%
CH387-4 (13/5)
RTB
CH387-4 (16/5)
RTB
CH911-1 (16/5)
MarkCut
CH1130-1 (16/5)
MarkCut
Avg
Remarks :
2.5 hrs operating rate observation
Lot Change Time :
Min : 6.5 min
Max : 23.0 min
Avg : 11.8 min


Burn-In Operation
Boards Checking
Operation
Operator Jobs
Time Taken
Burn-In
Boards Loading
16 min / 2 Lot
Boards Checking
80 min / 2 Lot
Boards Unloading
16 min / 2 Lot
ST = 1.60 hrs/kpcs
112 min / 2 Lot

Burn-In Operation

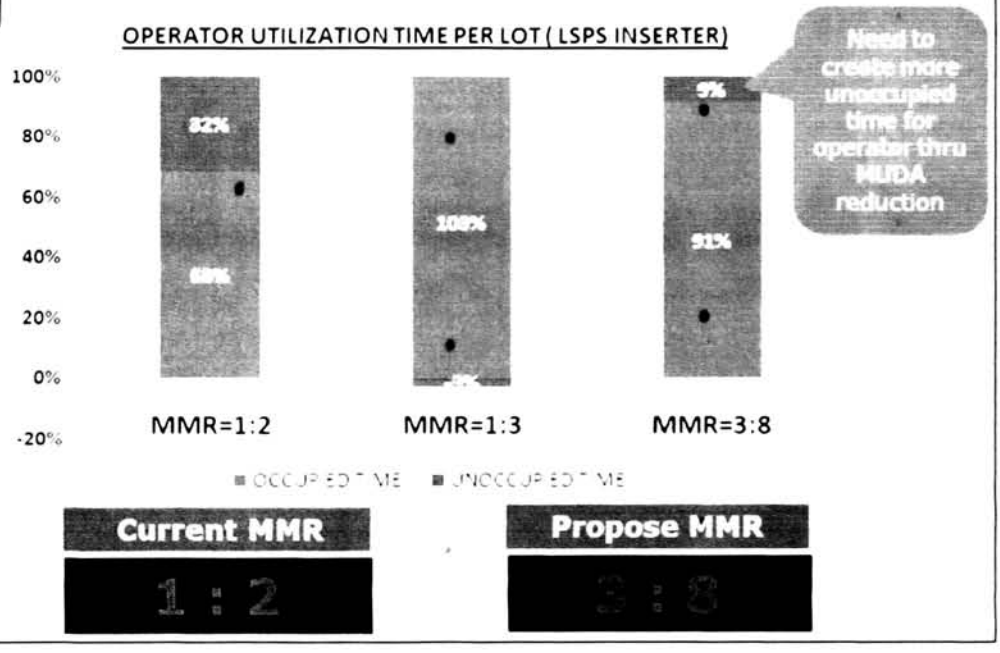
Detail explanation by working group leader.

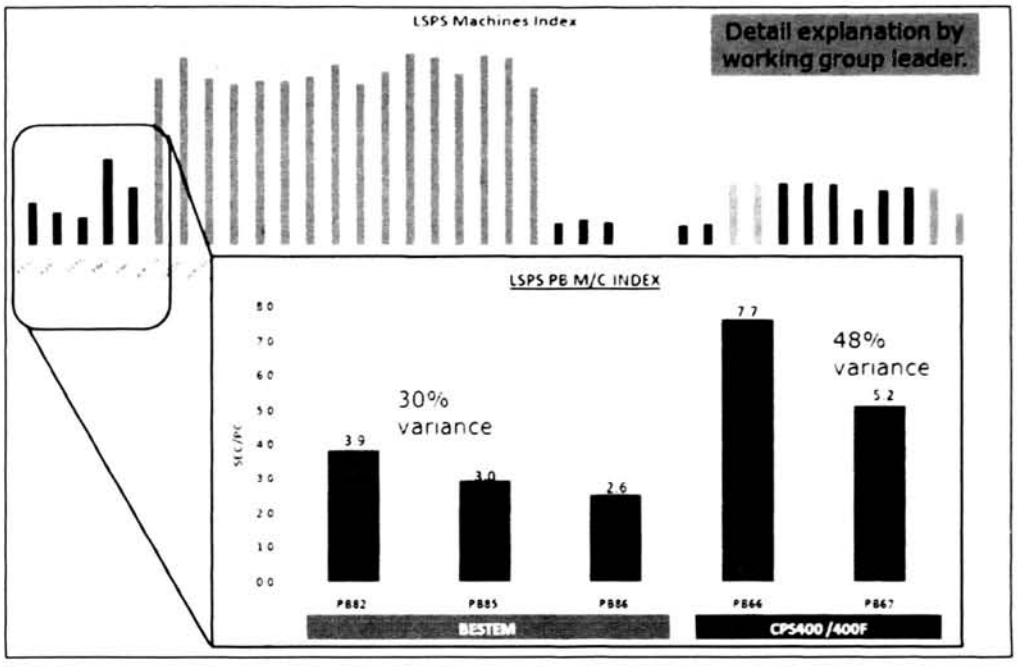


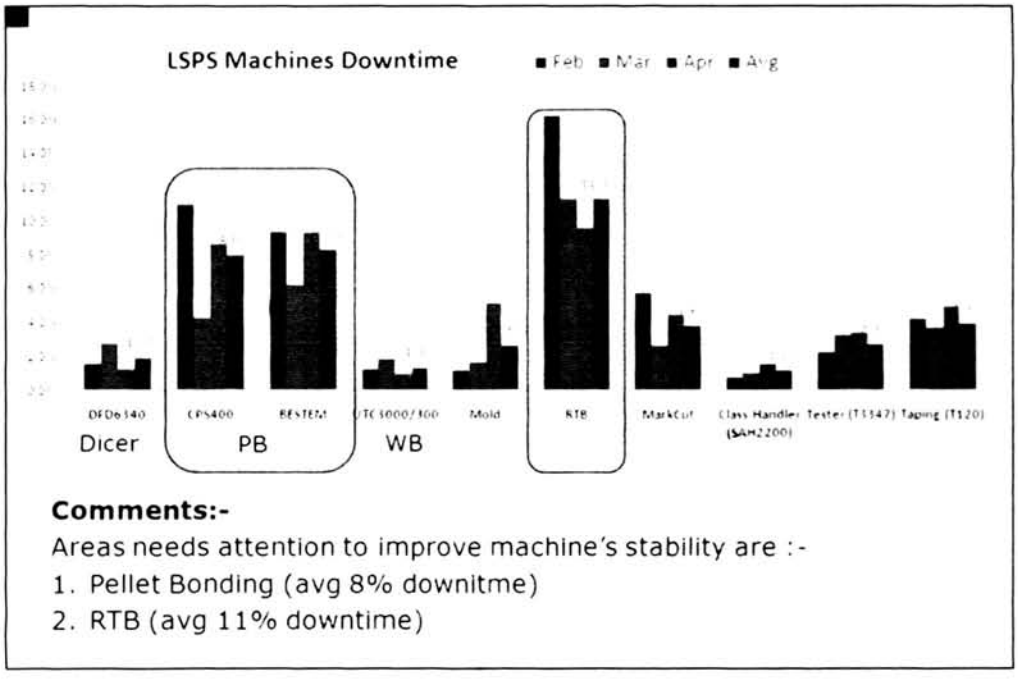
Comments:-

1. Long checking time due to operator needs to walk from back to front to see the test condition.

Inserter (Charging & Dis-Charging Operation)







Comments:-

Areas needs attention to improve machine's stability are :-

1. Pellet Bonding (avg 8% downitme)
2. RTB (avg 11% downtime)

LSPS AT/BT Improvement Plan

Main Focus :-

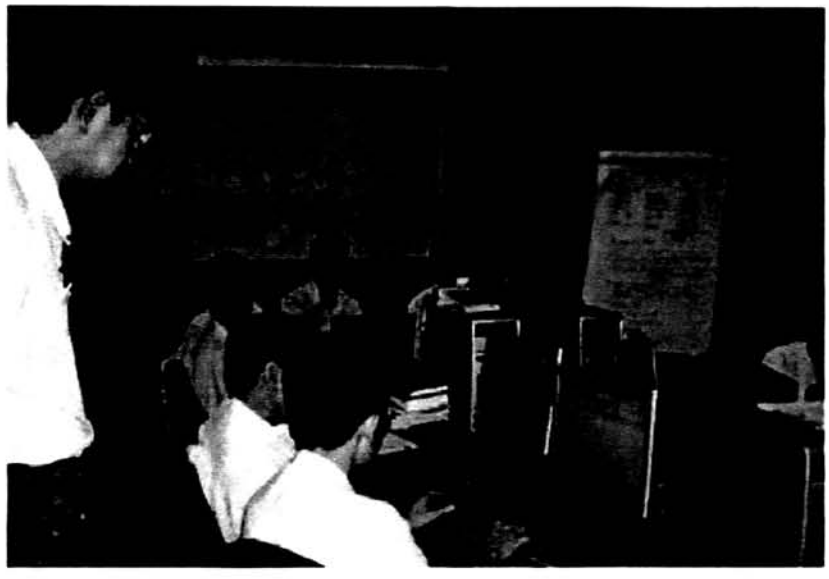
1.MMR improvement

PB (3:4 => 1:2)
Inserter (1:2 => 3:8)
Class T2000 (1:2 =>1:3)

2. Manual Operation Reduction.

a. Abolish Resin Removal.
b. Abolish SPVI.
c. FVI reduce sampling size.

Initial Training by iPS Group



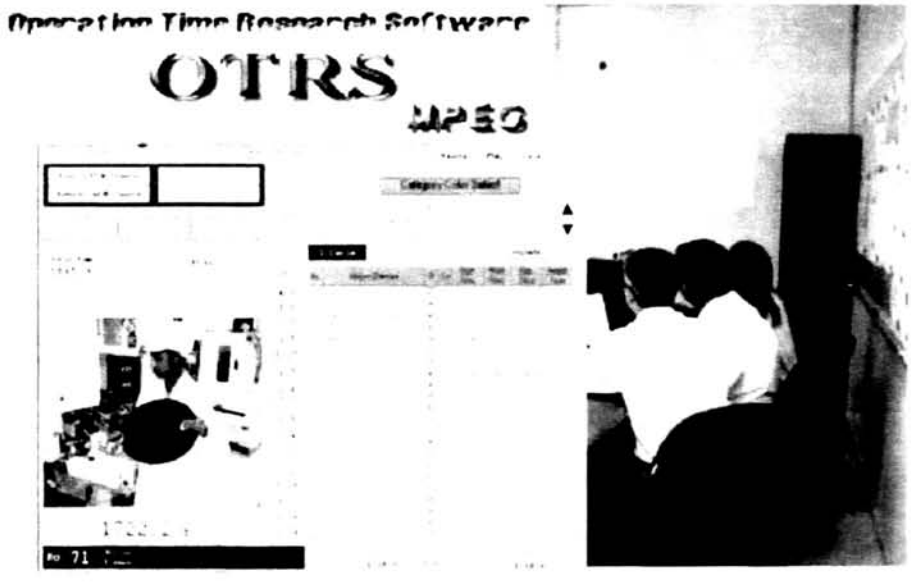
Training by OJTS

Training for Operators

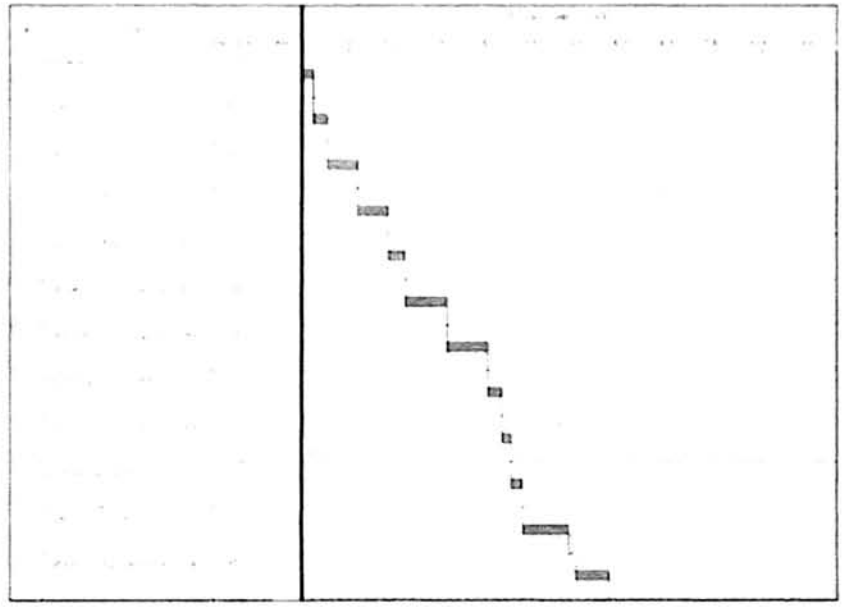
Innovative Production System *in LFPAK LINE*

Methodology : Observation – example Video Shooting

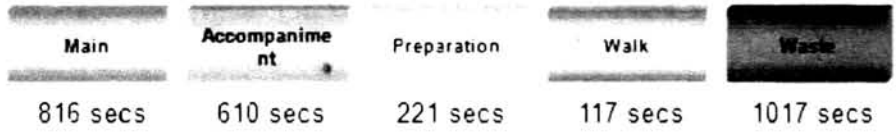
Methodology : Analysis thro' use of OTRS



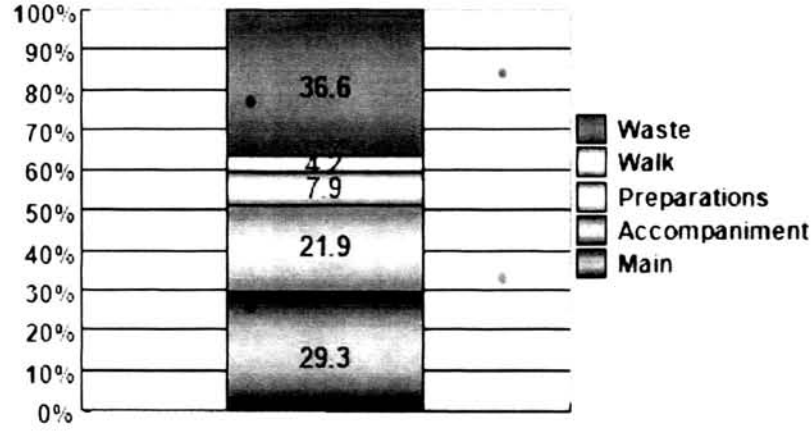
Methodology : Analysis



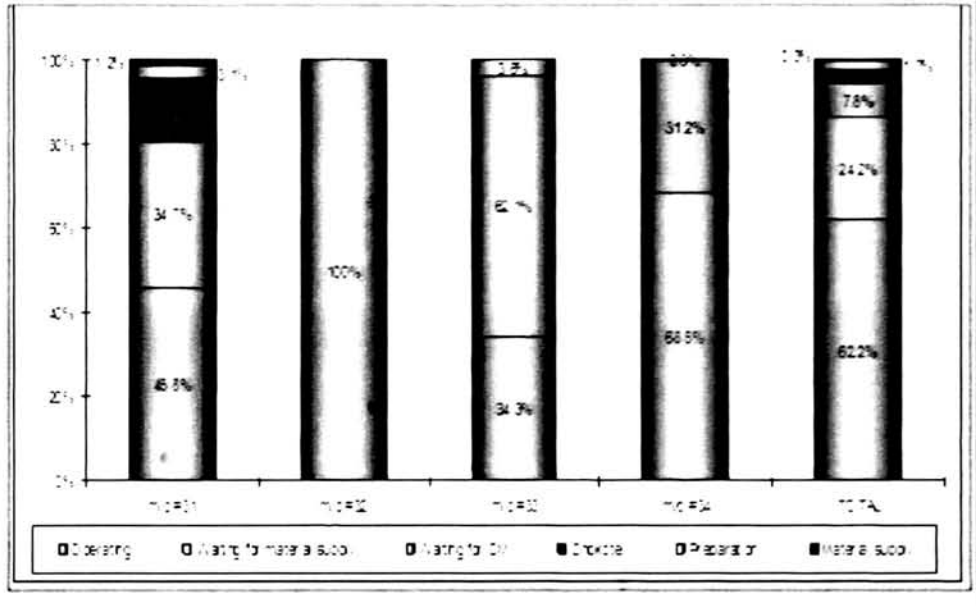
Methodology : Analysis



816 secs | 610 secs | 221 secs | 117 secs | 1017 secs



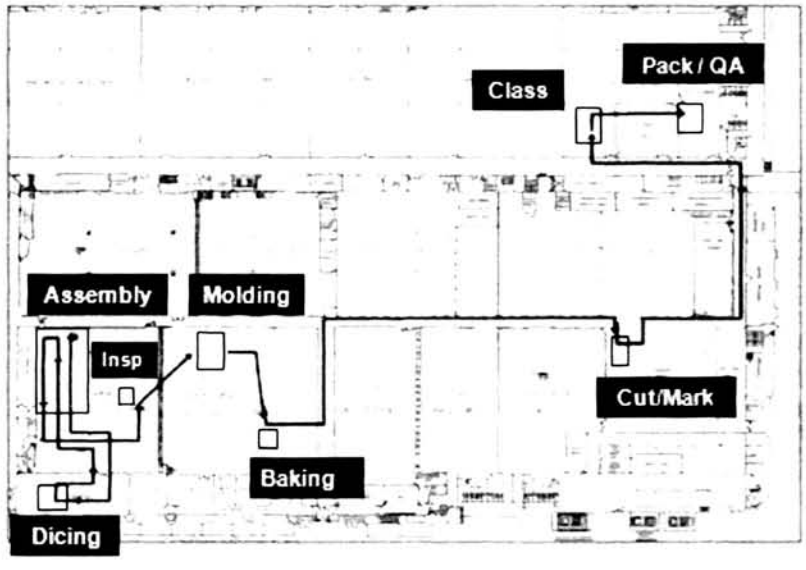
Methodology : Analysis



LFPAK – Layout (Before)

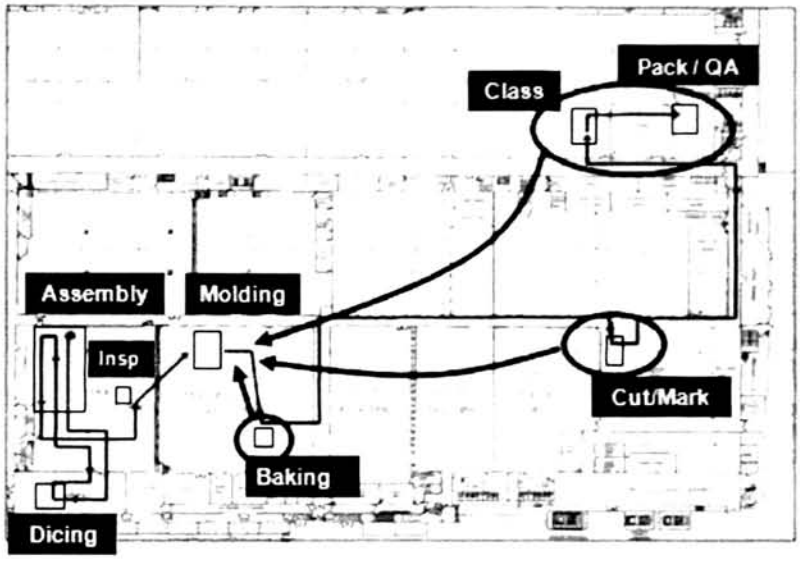
- Assembly to QA

Product Flow

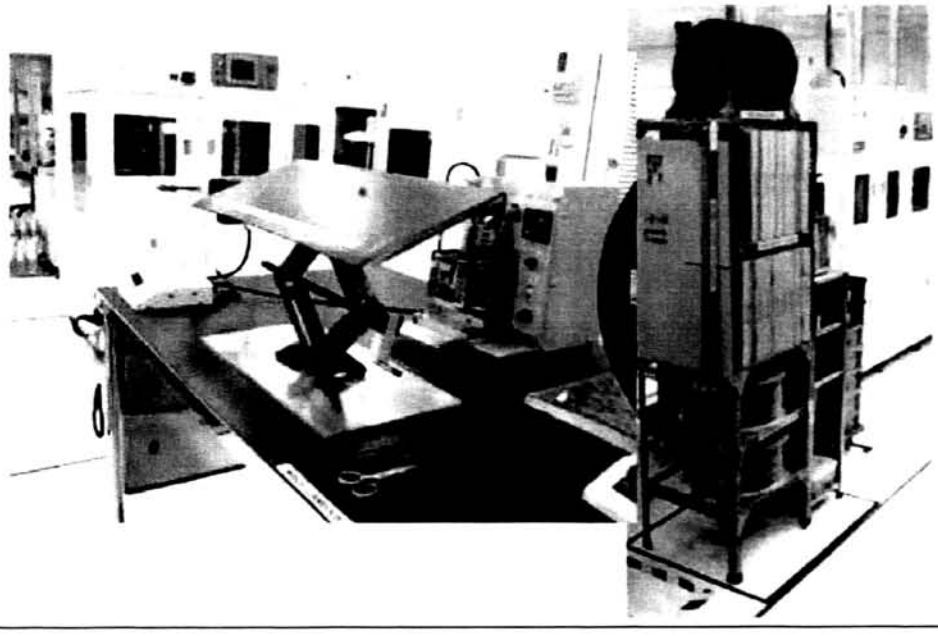


LFPAK – Layout (After)

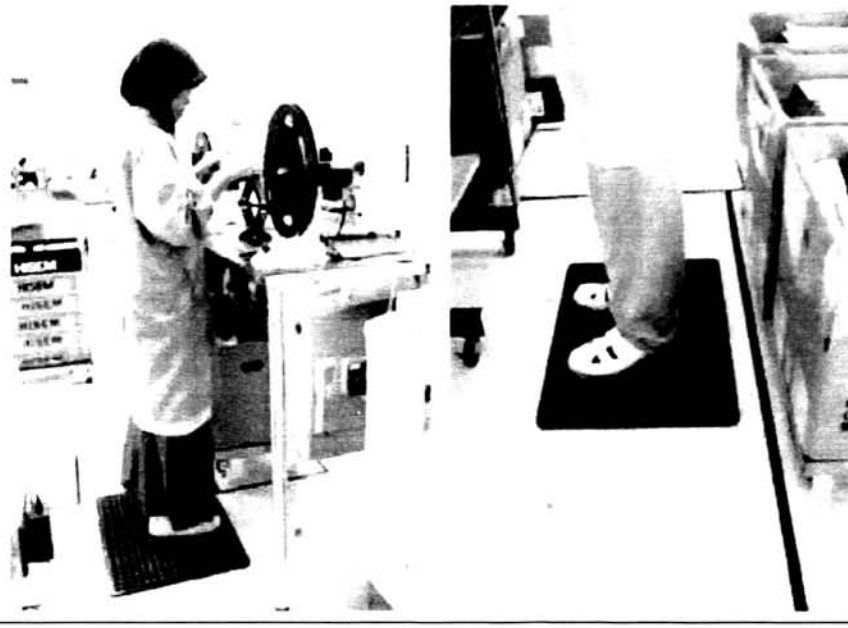
- Assembly to QA



DIYs – Purchases from Dept. Stores



Standing Operations & Anti-Fatigue Mats



Overcoming Ergonomic Issues

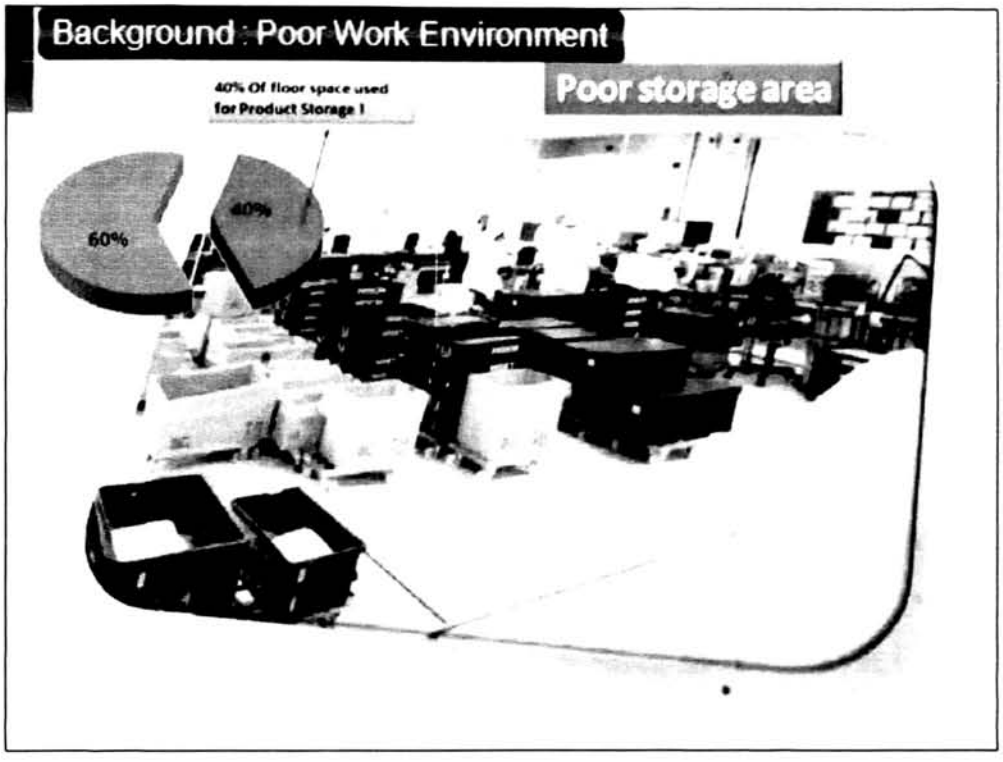
Poor Ergonomics

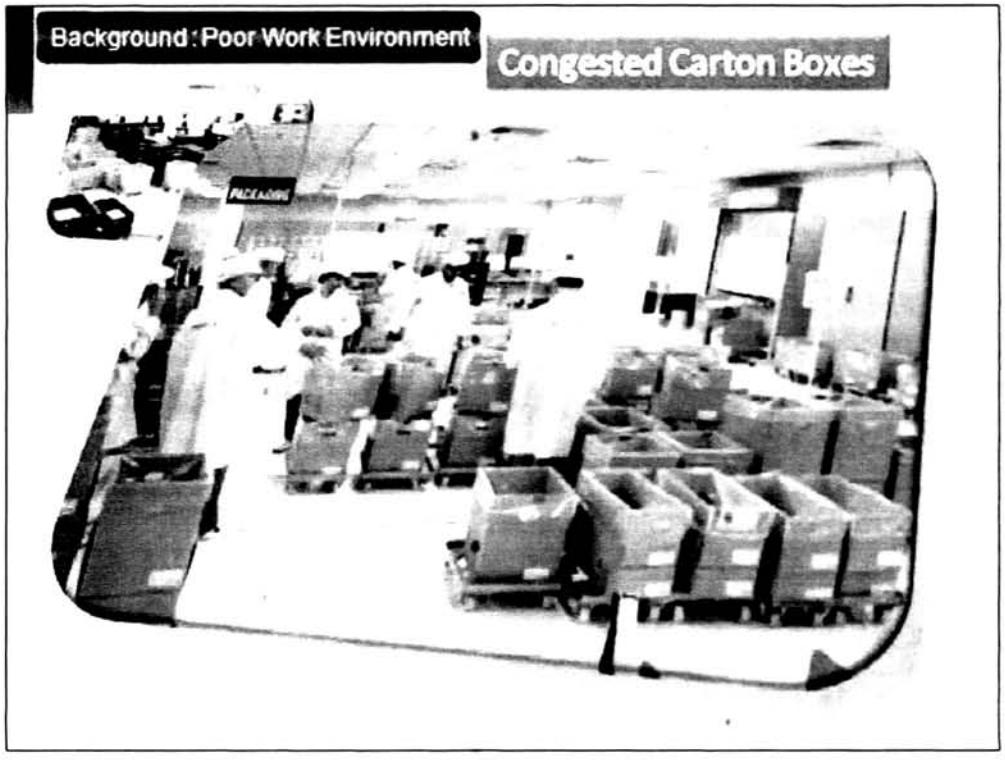
Improved Ergonomics

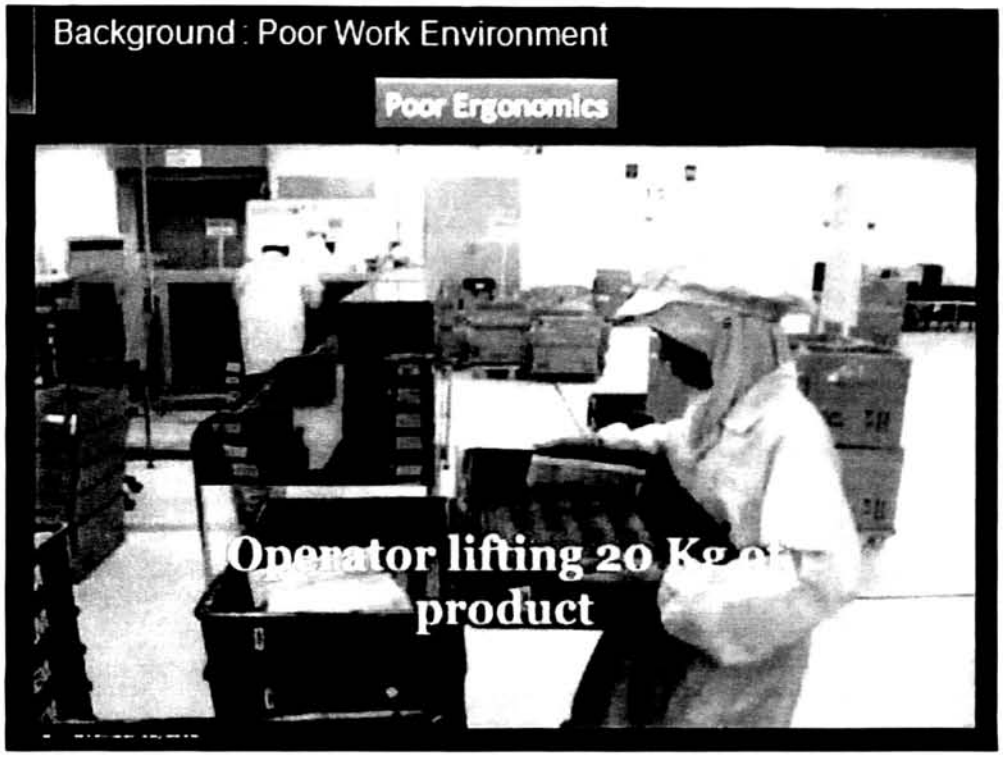
DIYs – Machine Indications

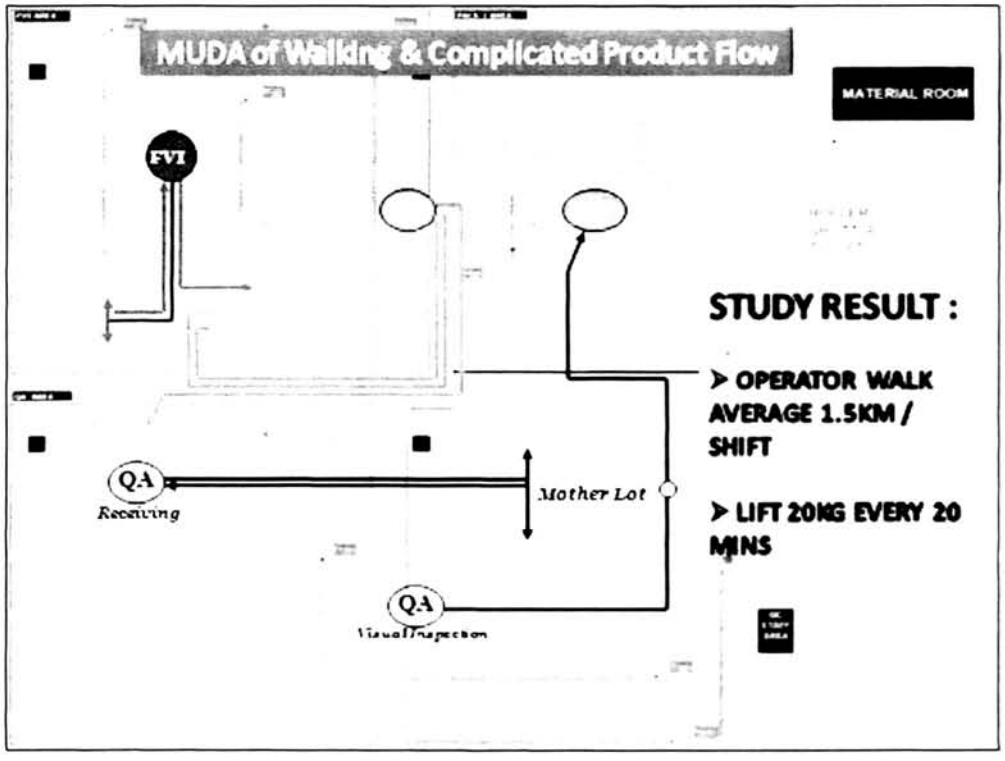
Merits

	Improvement Items	Before	After	Effect
Layout Change	Process Length (Feet)	947	162	83 %
	Operators' Steps	2107	421	80 %
	Standard Time (Hrs/kpcs)	2.36	1.85	22 %
	TAT Reduction (Hrs)	168 *	134	79%
Lot Size Reduction	TAT Reduction (Hrs)	134	36	
	WIP Index (Days)	7.3	3.6	50 %


Background : Poor Work Environment
40% Of floor space used for Product Storage !
Poor storage area
60%
40%

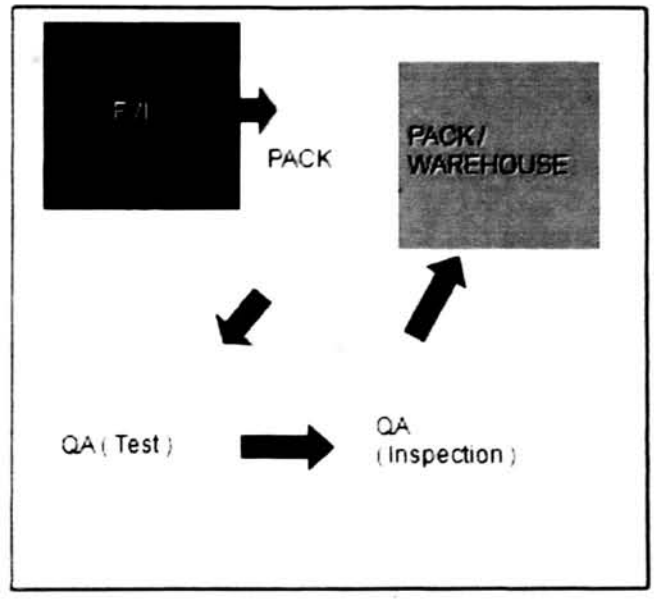

Background : Poor Work Environment
Congested Carton Boxes


Background : Poor Work Environment
Poor Ergonomics
product


MUDA of Walking & Complicated Product Flow
MATERIAL ROOM
FVI
QA
Receiving
Mother Lot
QA
STUDY RESULT :
➤ OPERATOR WALK AVERAGE 1.5KM / SHIFT
➤ LIFT 20KG EVERY 20 MINS

Background : Long TAT

Long TAT 27 Hrs mainly due to waiting time from process to process

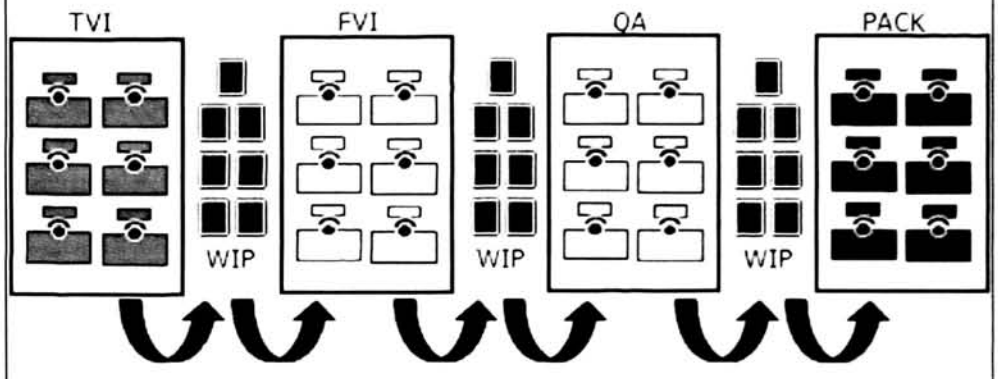


Objective :

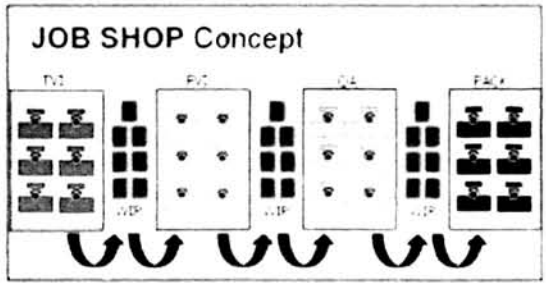
To convert Power Transistor FVI,QA & Packaging Process Flow from **JOB SHOP** to **FLOW SHOP** to Improve :

- ✓ TAT
- ✓ Visibility
- ✓ Ergonomics
- ✓ Space Utilization
- ✓ ST
- ✓ WIP

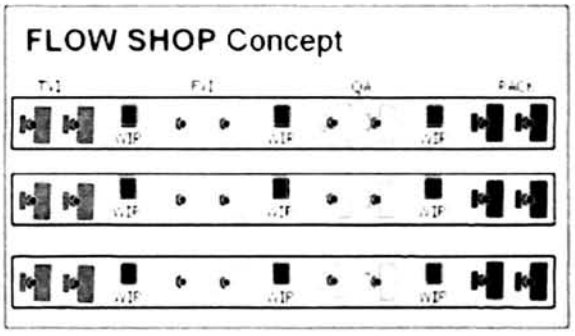
Background : Poor Work Environment



Analysis : Flow Shop

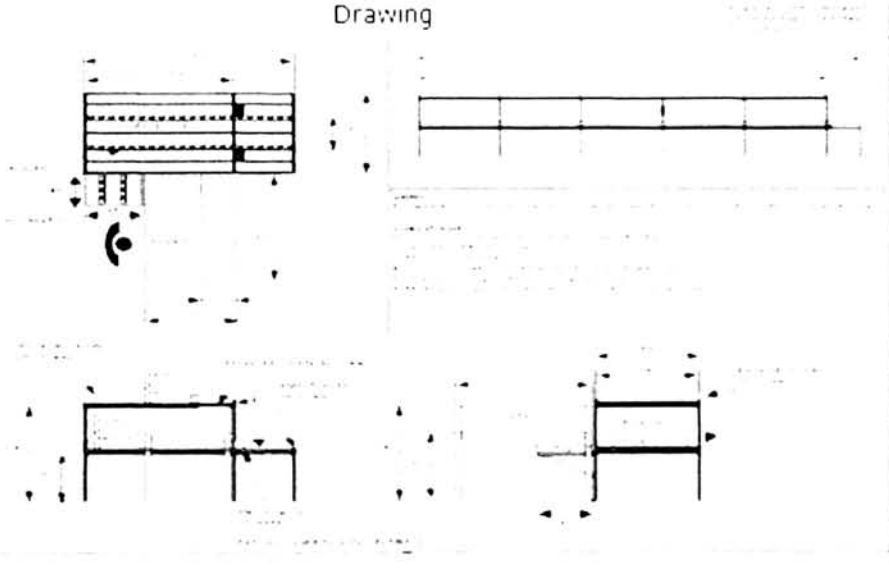


LESS WIP & FAST TAT



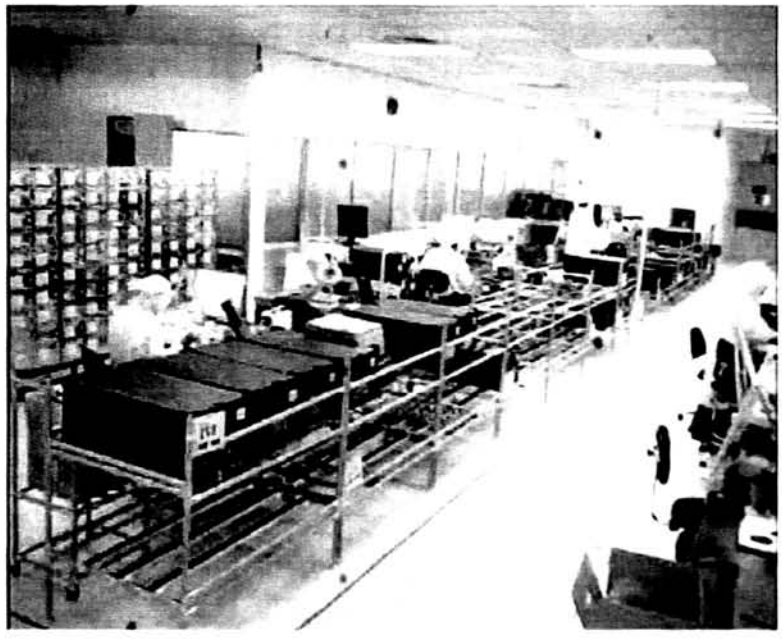
Innovation : 3 – D Simulations

Innovation : Conveyor Technical Drawing



Implementation : Taping Line

Implementation : Taping Line



Result :

	Before	After	%
Space Savings	525m2	413m2	21 %
TAT Improvement	27 Hrs	15 Hrs	44 %
Walking Steps	327 Steps	127 Steps	61 %

Project Objective & Target :

Objective
To reduce COMBO IC LEAD TIME
through introduction of
LEAN MANUFACTURING.

Target
To achieve 2Kc Lead Time for Combo IC.

- Reduction of WIP.

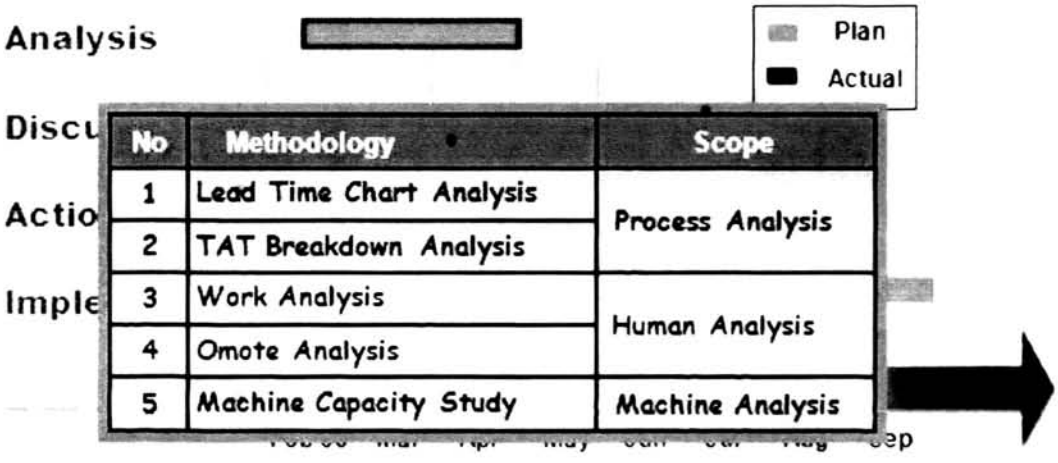
- Elimination of Muda in production line.

- Improve Critical Machine Operating Rate.

2

Strategy :

Combo TAT Reduction



No	Methodology	Scope
1	Lead Time Chart Analysis	Process Analysis
2	TAT Breakdown Analysis	
3	Work Analysis	Human Analysis
4	Omote Analysis	
5	Machine Capacity Study	Machine Analysis

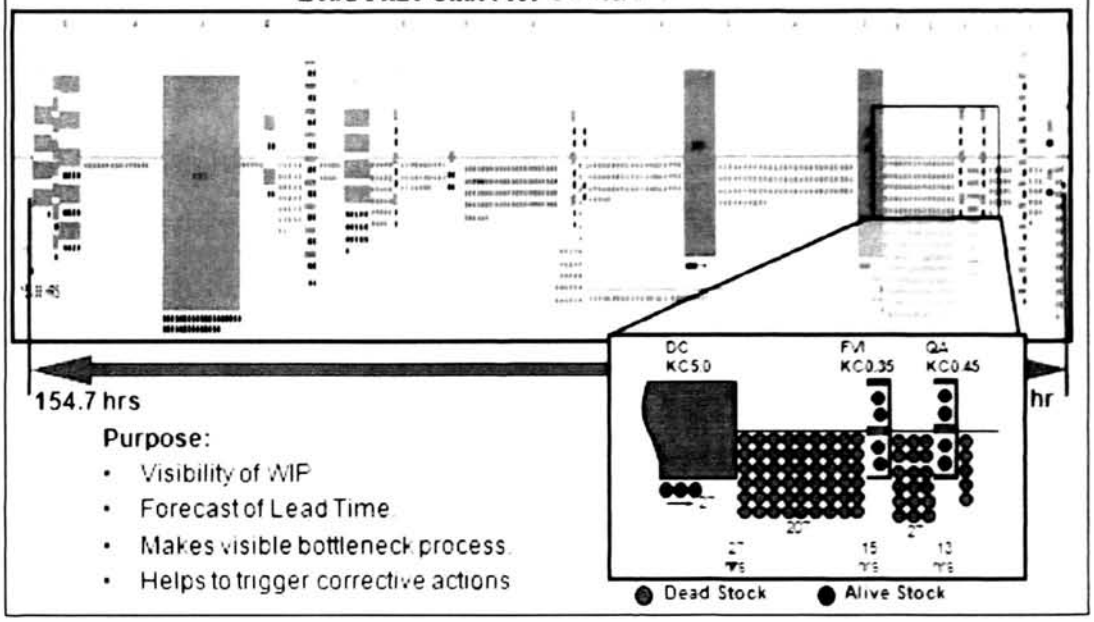
3

Methodology :

1st - Lead Time Chart Analysis

1st in RSM

Lead Time Chart for COMBO 3



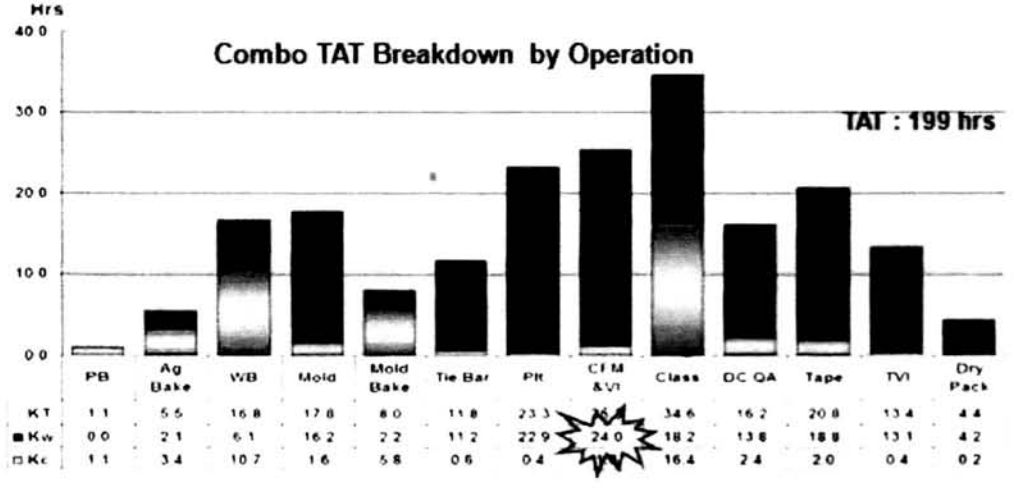
Purpose:

- Visibility of WIP
- Forecast of Lead Time
- Makes visible bottleneck process
- Helps to trigger corrective actions

Methodology :

2nd - TAT Breakdown Analysis

- To determine the actual Process Time (Kp) & Waiting Time (Kw) at each operation



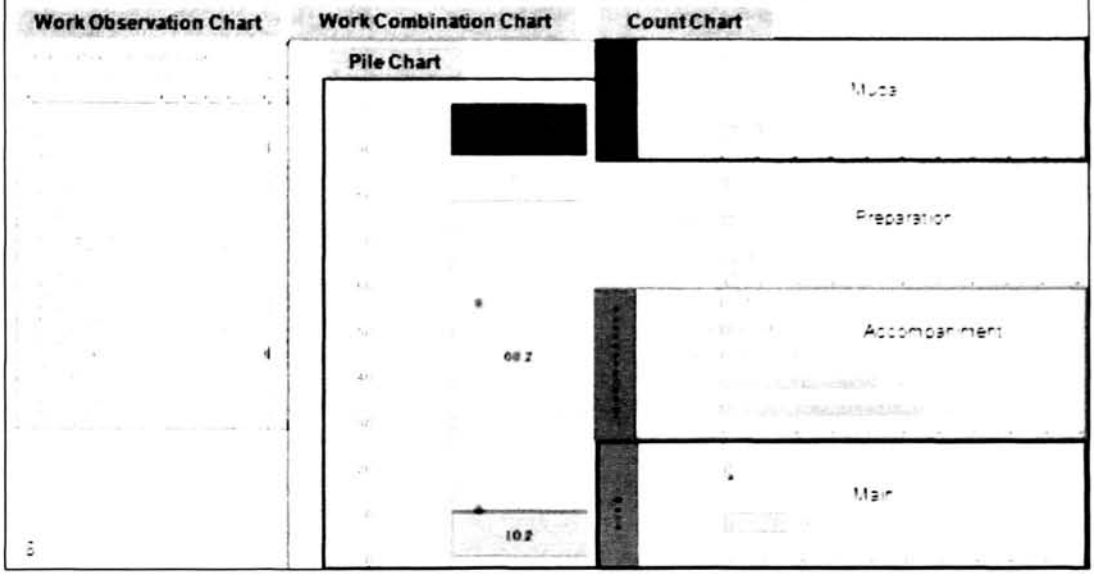
- Kw contributes 77% of TAT.

6

Methodology :

3rd - Work Analysis

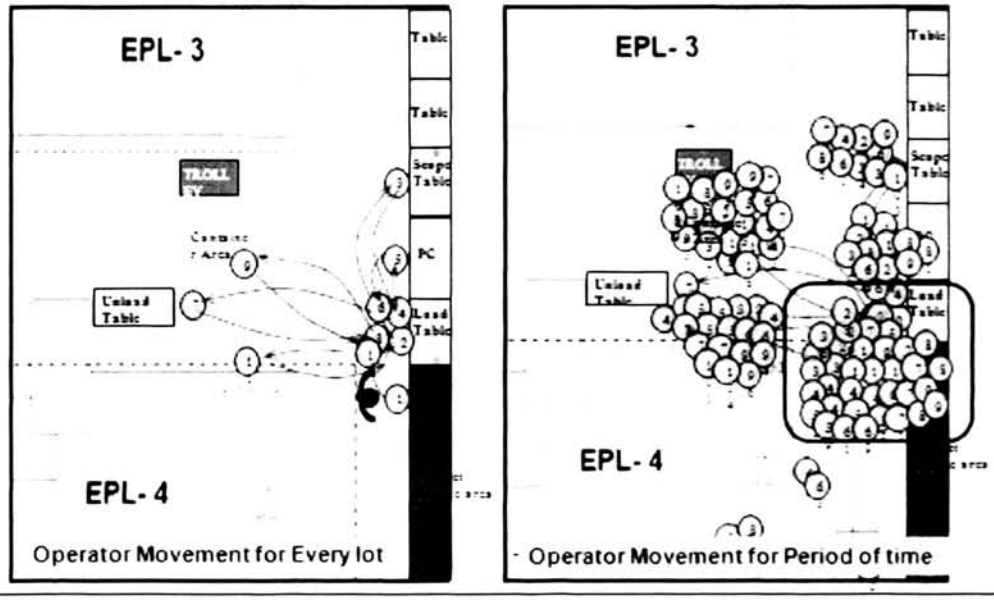
- To map the actual operation done by operator
- Breakdown operator s activities into 'Main' 'Preparation' 'Accompaniment' & 'Muda'



Methodology :

4th - Omote Analysis

To study the operator movement and identify 'Muda' of walking



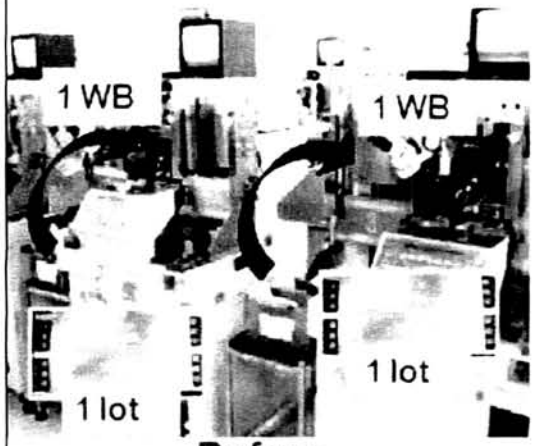
Technique of Improvement :

- Highlighted Projects

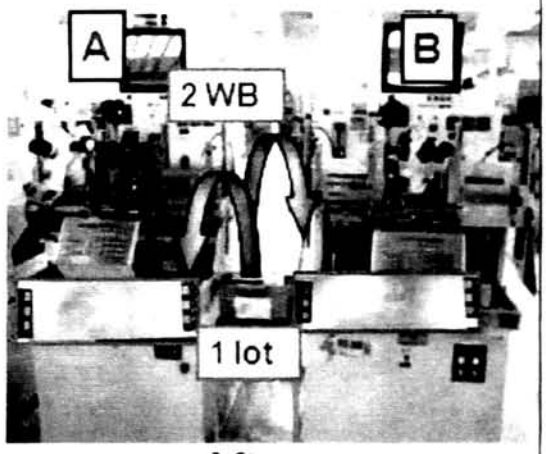
Improvement Items	*Operation*	*Objectives*
1) Process Re-layout	QA~Pack	Muda of Transportation
2) Lot Splitting at WB	Wire Bond & Mold	Muda of Inventory & Waiting
3) Visibility & Visual Control	All	Muda of Inventory & Over Production
4) CFM Thruput Up	Cut Mark Form	Muda of Inventory
5) Plating Work Improvement	Plating	Muda of Motion & Transportation

·2

Lot Splitting at Wire Bond **Wire Bond**



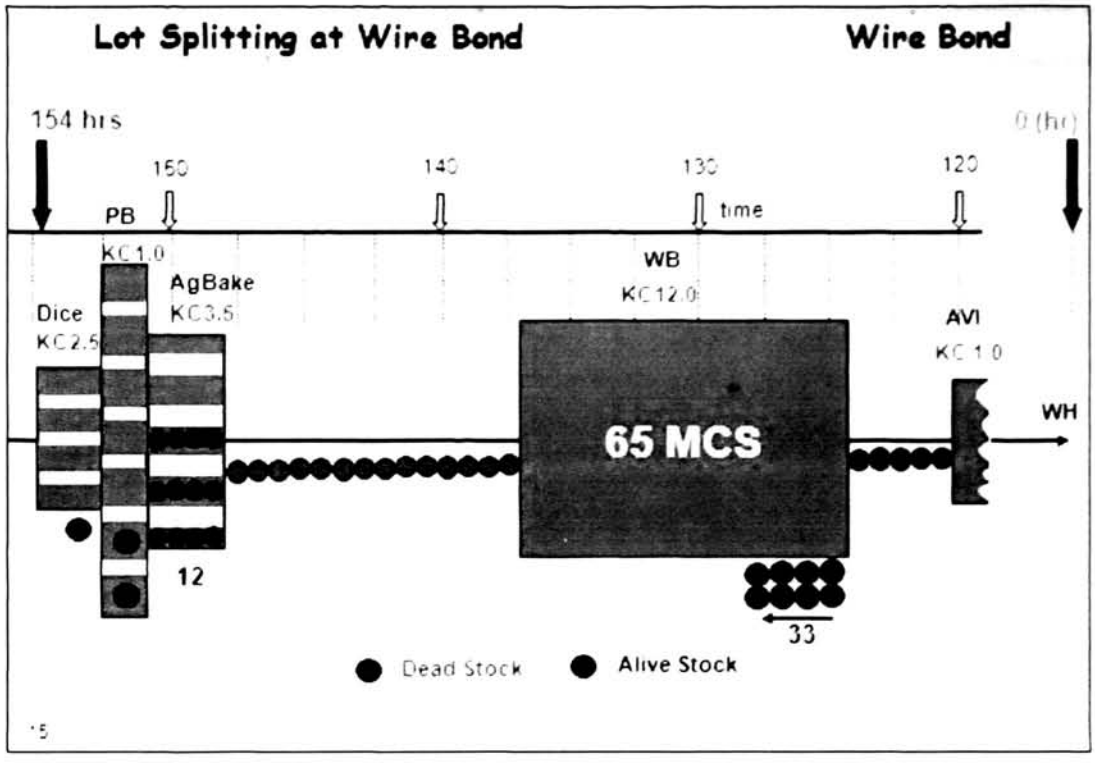
Before

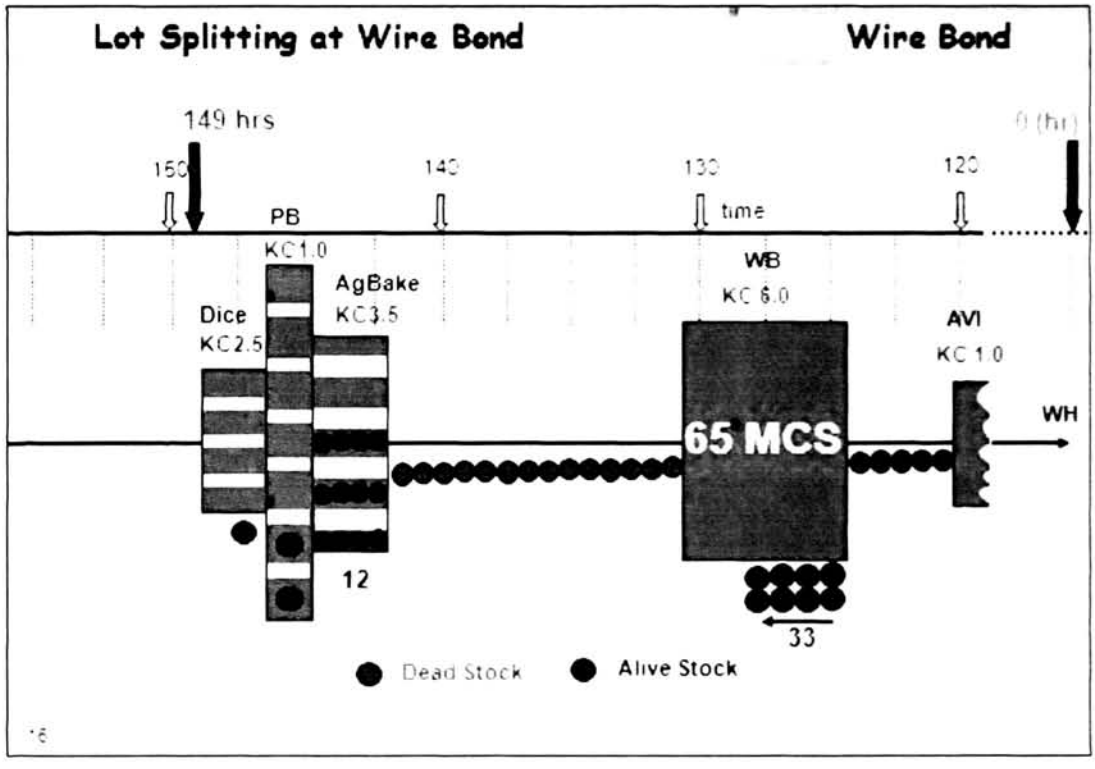


After

Kc per lot = 12 hrs ➡ **Kc per lot = 6 hrs**

·4


Lot Splitting at Wire Bond
Wire Bond
154 hrs
0 (hr)
150
140
130
120
time
PB
KC1.0
AgBake
KC3.5
Dice
KC2.5
WB
KC12.0
AVI
KC 1.0
WH
65 MCS
12
33
Dead Stock
Alive Stock
5


Lot Splitting at Wire Bond
Wire Bond
149 hrs
0 (hr)
150
140
130
120
time
PB
KC1.0
AgBake
KC3.5
Dice
KC2.5
WB
KC 6.0
AVI
KC 1.0
WH
65 MCS
12
33
Dead Stock
Alive Stock
6

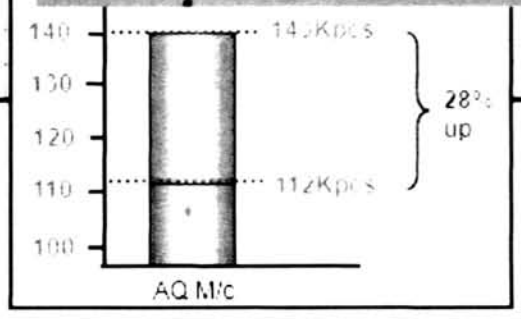
CFM Critical Machine Thruput Up

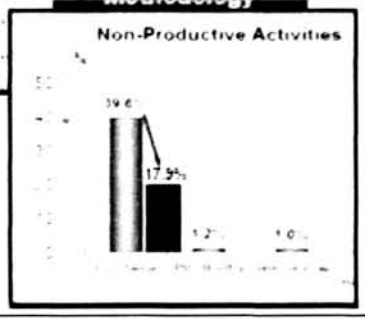
Mark/Cut

RESULT

Saving

No	Items	Before	After	Effect
1	Lot Changeover (min)	9	3	↓ 67%
2	Daily Capacity Per Machine (Kpcs)	112	143	↑ 28%
3	Standard Time (hr/Kpcs)	0.284	0.221	↓ 22%
		Saving		8.9 KRM



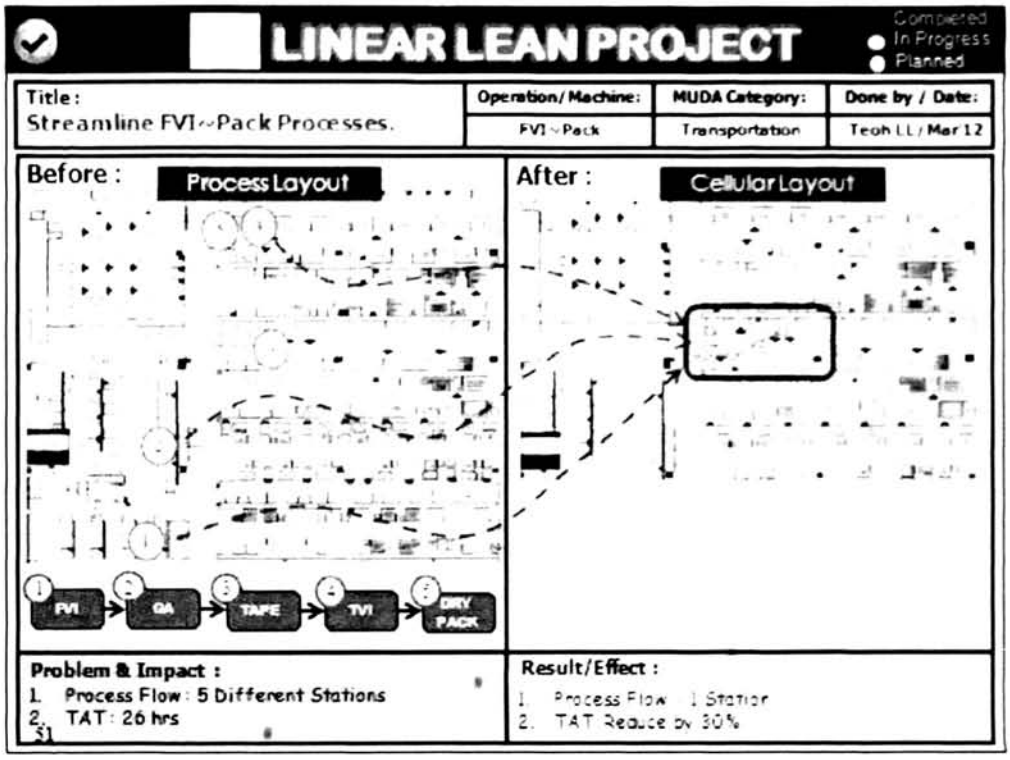


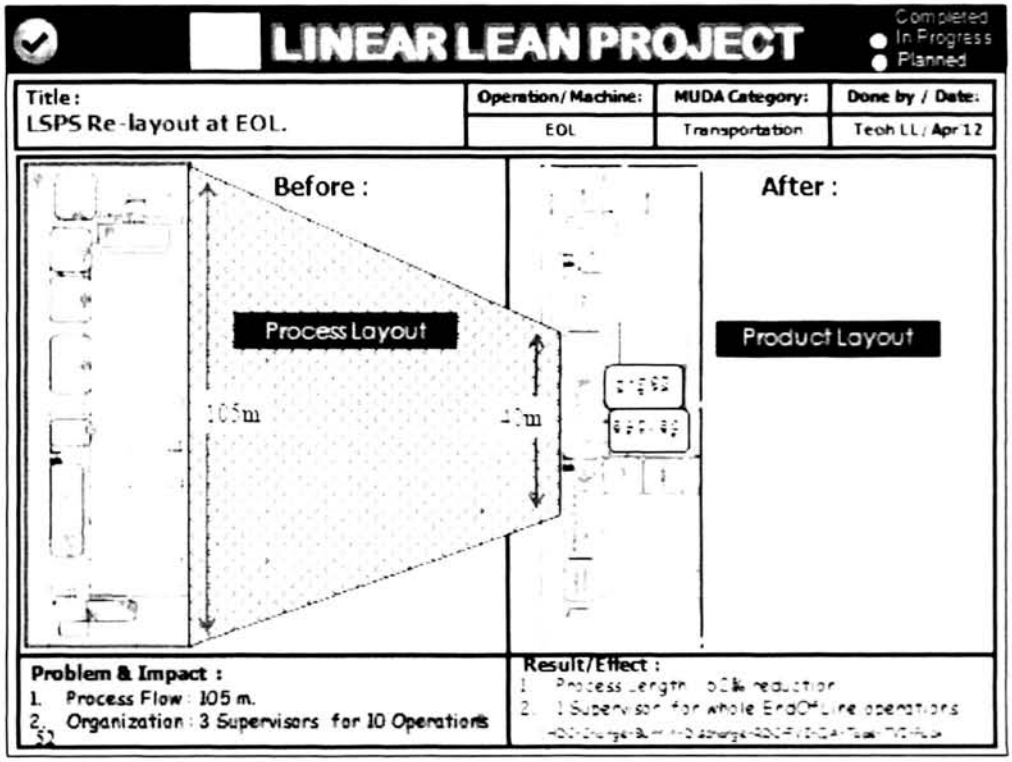
Conclusion :

Overall Tangible Benifits :

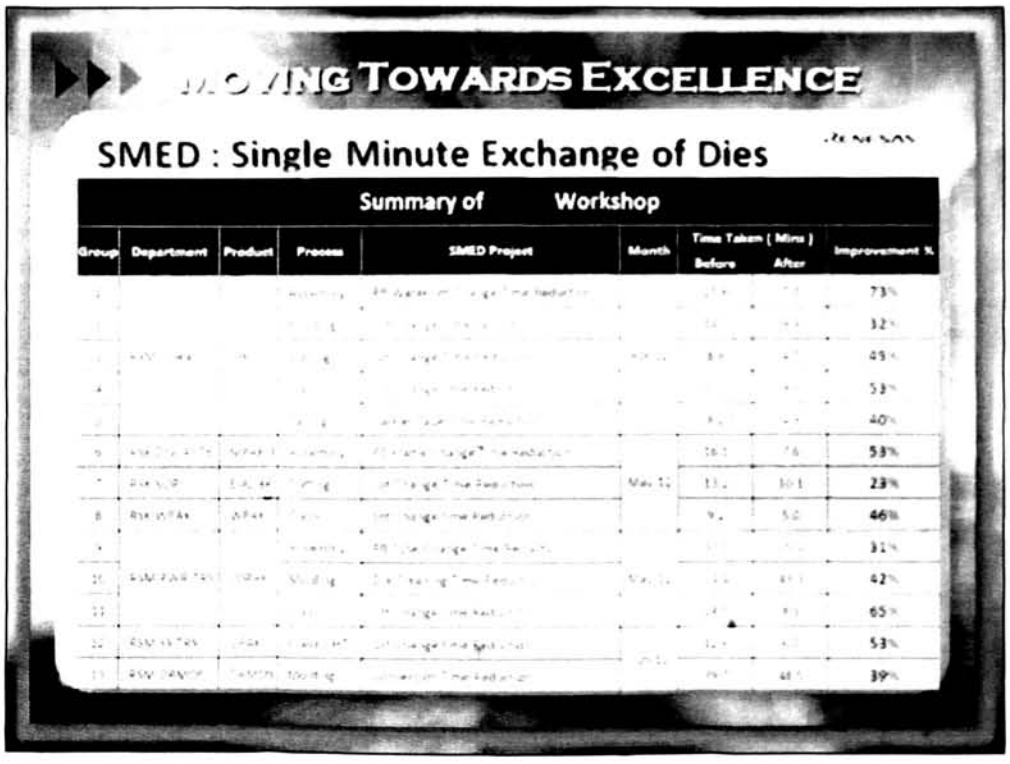
Improvement Items	Before	After	Effect	Saving
TAT	199 hrs	100 hrs	50% ↓	-
WIP on Hand	10.8 days	5.4 days	50% ↓	RM10 K
Productivity (CFM)	112 K /shift	143 K/shift	28% ↑	RM8.9 K
MUDA Reduction (Plating) Time Spent per Lot	25%	[illegible]	[illegible]	[illegible]
Free Space (Linear EOL)	Nil	+47.2 m²	-	RM1.3 K

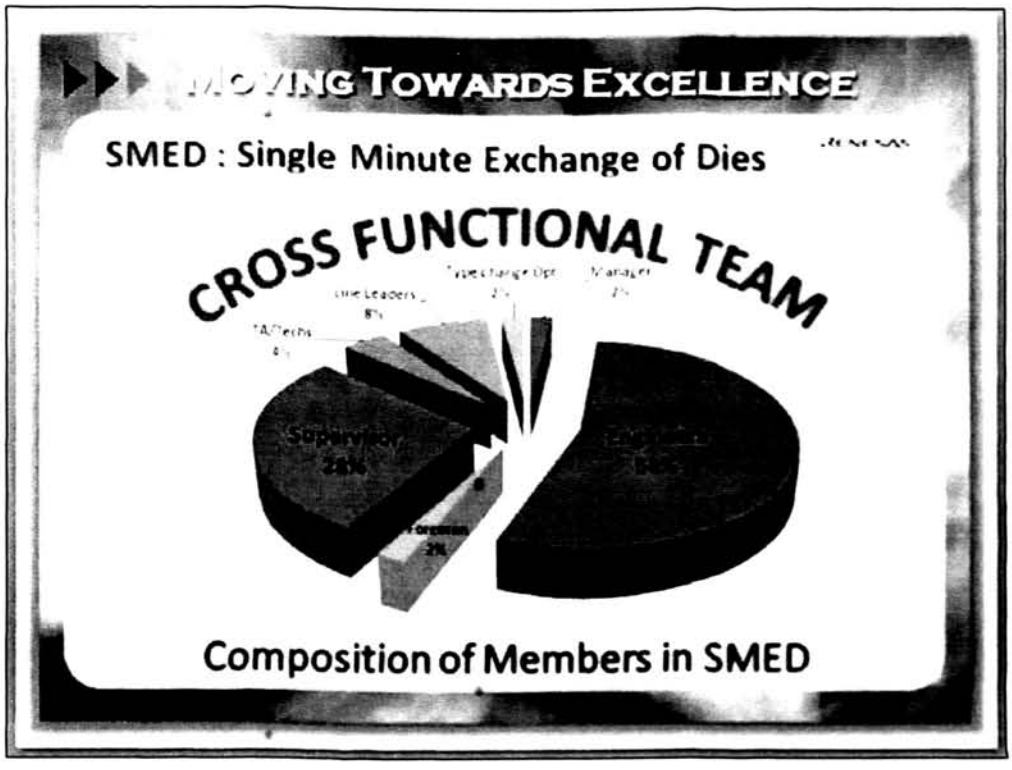
APPENDIX 7: EXAMPLES OF LAYOUT IMPROVEMENT





APPENDIX 8: SMED ACTIVITY





What is SMED :

Single digit : 0 ~ 9
Single Minute : Below 10 minutes

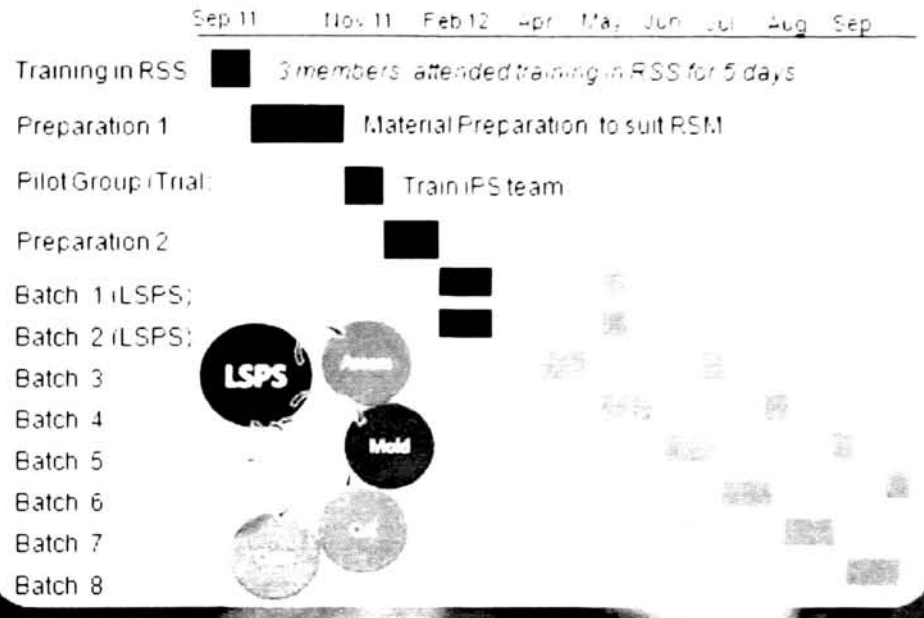
SMED is a set of techniques that make it possible to perform equipment set up and changeover operations in under 10 minutes – in others words, in the single minute range.

Quick Change-Over

SMED : PROCESS STEPS

Shigeo Shingo
Chief Engineer of Toyota
(in the late 1950's~1960's)

SMED : Master Schedule



November 12, 2012 9

SMED : Graduation & Recognition

November 12, 2012 16

APPENDIX 9 : INTERVIEWS (VERBATIM)

Input from respondents interviewed (Verbatim):

Cellular Layout

1. Yes, Cellular Layout does improve the efficiency of the operation or process. By removing waste (MUDA) in the process through improved work station there is better flexibility.
2. Cellular Layout reduces WIP as it restricts the space allowed for storage. In this way when WIP builds up it becomes evident and the situation is escalated up. With less WIP TAT shortens and the cash flow improves as total WIP now reduces and thus holding cost is down
3. When demand changes the number of cells can be adjusted to fit the demand
4. Cellular Layout enable more flexibility in production quantity changes
5. There is quicker information flow as people are in closer proximity and there is less physical hindrance towards communication
6. With multi-skill the shop-floor members could now enlarge their job scope. Though skill up time takes longer then before the overall benefit of operating a cell with different varieties of machine provides a mutual benefit to both management and operators.
7. Not only cellular layout improves the product flow. Even our conventional layout also improves the flow.

5S

1. With 5S implemented abnormality becomes easy to see and find out. Example when we see a screw missing on the machine cover it is considered abnormal.
2. Searching time have reduced as things are now in its place, instead of having to waste time looking for it
3. Information Flow improves indirectly. Example instead of spending so much time trying to describe a location of an equipment, we now just need to point to the clearly indicated equipment number which can be seen from far. This saves communication time as well improves its effectiveness
4. We practice allocating a place for everything needed for a task (example cellophane tape, tweezer, calculator etc), labeling each items (example by indication or a demarcation such as for tools), defining the quantity (example the number of raw material that is supposed to be there) allowed
5. One good practice we have here is the daily 10 minutes allocated for 5S in our workplace. In these 5 minutes everyone from top management to shop-floor operators would stop work and do 5S in their workplace. This is good culture and allows for official time off to make sure workplace is in good order
6. By constantly removing unwanted items from the workplace we avoid cluttering. This is important in eliminating the waste of searching time. Furthermore it free up space for more useful functions
7. An example of our 5S is in the way documents are filed in an orderly manner. When there is a customer request such as a customer claim, we are able to

retrieve the required document in a very short time. This help in the customer response time

Visual Management

1. I believe that "Mieru-ka" (Visual Control) is very important in improving the operation
2. By clear visibility in place everybody understand the situation
3. WIP management becomes easier through visual management
4. Examples of Visual Management practiced are light Andon (Signal Tower) for all equipment used. It not only tell the status of equipment whether it is operating or not operating but also it inform the necessity to load material. With this visual help the operators know where they need to concentrate on.
5. Many kinds of charts such as Gantt Chart, Production Progress Chart etc are commonly used here
6. We have on display both manually and on LCD screens the status for KPIs. In this way all members can know the current situation such as whether we are doing well in term of Turn Around Time (TAT), Production Status etc
7. ICT is a very important tool for Visual Management nowadays. With computerization many more information are available which help in the operation. It tells the status in real time and thus makes decision making easier.
8. We also have Mieru-ka by auto email
9. Though in lean manufacturing we preach pull system, there are some products that the TAT is so low that we now use push instead. We have come to this level with many efforts but Visual Management is a key to the success.
10. Our latest advancement in ICT enables us to tab signals from machines and make it visible on the screen for all to see and act on. We call this ATLAS (Assembly and Test Line Analysis System). It is a powerful visual tool for better management of our equipment
11. Last time when there is a partition separating my process from my previous process, I communicate with my colleagues through the intercom or telephone. However now without the partition I can easily speak to him and we seldom have miscommunication compared to previously
12. As a manager I find that without the partitions things are exposed rather than hidden. This help in making situation clear and will prompt us to take appropriate actions
13. Walking distance has definitely being reduced with no physical partition blocking my path, it is great
14. With the use of Information Boards I am able to know the line situation quickly. We meet around the board daily and this is very useful for me as a supervisor.

Teams

1. Operators have the opportunity to work in groups through the Kaizen Innovative Team activity. These are teams formed at shop-floor level ranging from 6~10 members per group. Their task is to discuss ways to improve their workplace issues such as quality problems, productivity problems, safety etc
2. The suggestion scheme in this Kaizen Innovative Team activity allows for the shop-floor members to make practical proposals on how the workplace could be improved. The groups make proposals on topics such as how to improve the TAT, Improve Changeover time so that there can be more conversions to meet customer requests, Overcoming difficulties as a result of new specifications requirement etc
3. In the monthly meeting of the groups the agenda also includes update of latest information from the company. Customer complaints are also highlighted. It is also a good time for understanding each other's difficulties in work. By meeting and discussing together there is a greater bond among us. We also bond well as we receive monetary awards for the suggestions made and from this award we have outings together.
4. Cross-functional teams are common in this place. Example we have the SMED (Single Minute Exchange of Die) activity where the groups consist of operator, supervisor, technicians and engineers. Changeover time has improved significantly in many cases and this helps us to be more flexible.
5. Due to the group working together as a team to solve problems or to improve current work situation, the barrier earlier faced in our communication has reduced drastically.
6. In the past there has been much complaint on the shop-floor on why there are so many requests for type change in the production line. Even though there are still complaints the level of understanding has improved as to why the organization needs to respond to the customer's request. Teams allow for such information to flow down till shop-floor level

Organization Structure

1. Even though we try to have as few levels as possible it is rather difficult because we need to balance up with motivation of long serving members
2. In a few cases the vertical organization structure (instead of horizontal) improves the flow of information. It also helps in execution of changes requested.
3. Last time I have to communicate to 3 supervisors in order to execute a change request (such as customer request), but now I only communicate to one person. This makes it not only easier but less issue with accurate communication
4. When the resignation level is high we have difficulty in replacing the person who resigned if her scope in terms of the number of processes is many.

What is 5S?

"5S" refers to the five steps of housekeeping. It originates from the Japanese words "Seiri", "Seiton", "Seiso", "Seiketsu" and "Shitsuke". It is a common-sense, low-cost approach to improvement. In general, it is saying:

"Good Housekeeping In Five Steps".

SHITSUKE
SEIKETSU
SEISO

The English equivalents of five Japanese S's are:

Seiri	◄ ►	Sort	◄►	Clear Out
Seiton	◄ ►	Straighten	◄►	Tidiness
Seiso	◄ ►	Scrub	◄►	Clean / Check
Seiketsu	◄ ►	Systemize	◄►	Conform
Shitsuke	◄ ►	Standardize	◄►	Custom Practice

SEIRI

Concept:

Distinguish between necessary and unnecessary items

Discard unnecessary items leaving only minimum number required

Remember!

Only a small number is required in daily work.

Too many pens, pencil and paper. We should decide how many to keep e.g. 2 pens, 1 pencil and 1 pad of paper. The rest are kept in a storage area.

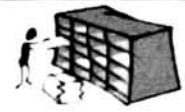
Effect:

- **Eliminate the need to shuffle through the unneeded items**
- **This process develops self-discipline**

Storage area for unused chemicals

Empty containers are placed separately

SEITON



Concept: Arrange all items after cleaning (**SEIRI**) in an orderly manner

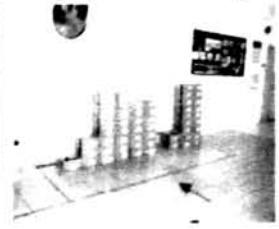
Put all things in order for easy access, classify items by use e g address, name, designated area, special marking

Easy access with minimal search effort

By address

By name

By special marking



Effect:

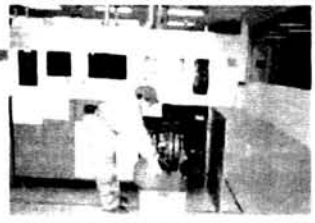
- Minimize search time and effort
- More time can be spent for effective work
- Reduces industrial accidents

Passage is clear with all items placed within demarcation lines

SEISO

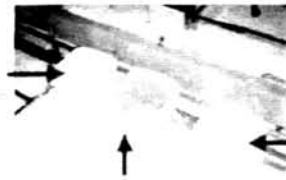
Concept: KEEP MACHINES AND WORKING ENVIRONMENTS CLEAN

Clean everything. Eradicate sources of dirt



Clear unwanted waste from machine

PLACE ALL RUBBISH INTO PROPER WASTE BINS



Effect:

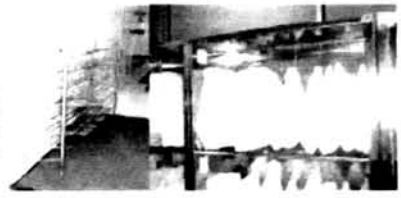
- Work place is neat and looks pleasant
- Operator can make many useful discover
- while cleaning machines
- Increases machine reliability

SEIKETSU

Concept: Extend the concept of cleanliness to oneself (keeping oneself clean)

✓ Continuously practice these 3 steps everyday. make cleaning and checking a routine

Good discipline with chairs pushed in

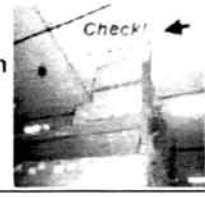


Place shoes and attire at the designated areas

Maintain a clean and neat working table

Effect:

- Improve employees' self- esteem
- Maintain a clean work place



Arrange items according to guidelines – at the specific place and do not stack above allowable height

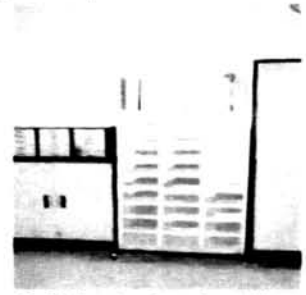
SHITSUKE

Concept: Build self-discipline

Make the steps as a process that never ends and can be improved upon.
Establish standards to engage habit of 5S

5S Improvement

Machines, equipment and products are aligned neatly and placed within the demarcation lines



Sufficient cabinets with proper labels for storage of materials and documents

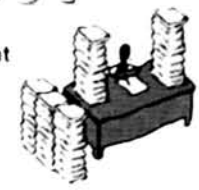
Effect:

- Boost the morale of workers
- Promote and strive toward betterment of self and the work environment

5S Challenge Trophy

Benefits of 5S

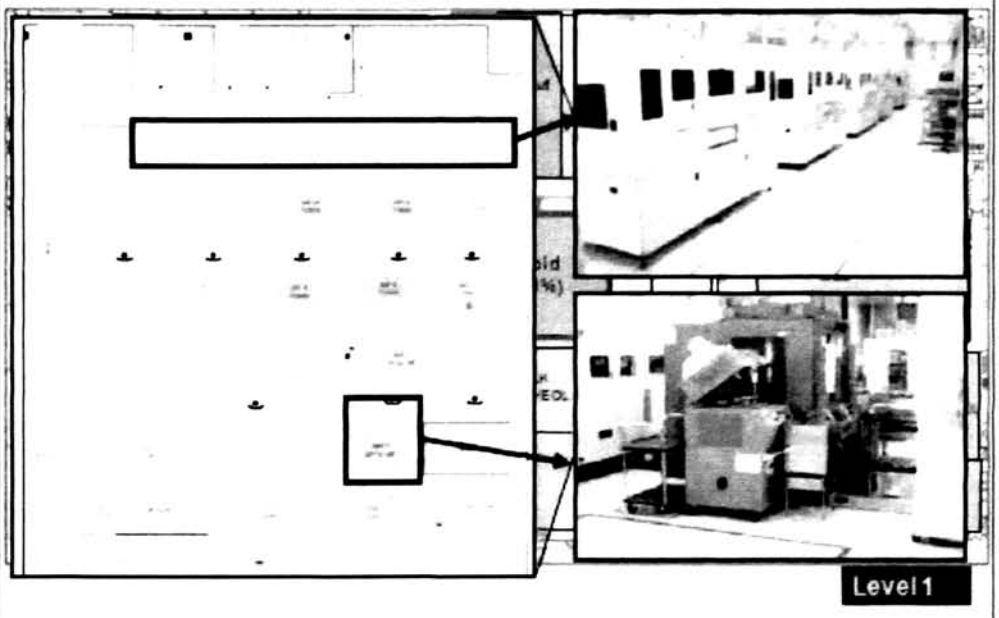
- Create a clean, pleasant, safe working environment
- Free up space
- Eliminate various kinds of waste
- Reduces industrial accidents by eliminating oily and slippery floors, dirty environments and unsafe operations
- Minimize the need to search for tools, therefore make operators' jobs easier
- Improve work efficiency
- Employees acquire self-discipline
- Improve employee morale and motivation



" Make **5S** a way of life in our daily work "

APPENDIX 11: LAYOUT OF MACHINES

Example of Layout in Case Study Site - 1



Example of Layout in Case Study Site - 2

APPENDIX 12: KPI DISPLAYS

LINEAR LEAN PROJECT

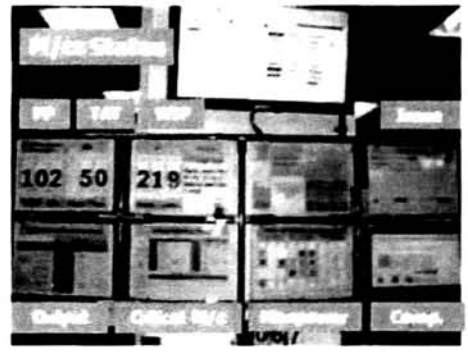
Completed
In Progress
Planned

Title: Mieruka Board	Operation / Machine:	MUDA Category:	Done by / Date:
	All		TeohLL / Mar12

Before :

Line has no information of :
1 Production Progress - delay or advance
2 Machine Performance & Progress
3 Quality issue
4 Manpower issue

After :



To create awareness among line staffs and operators to keep track production progress. To level production, help workers keep our daily production.

Problem & Impact :
There is no feel of urgency if any abnormality occur.

Result/Effect :
Better visibility to create better awareness in the line.

49

KPI Display Training

To train LSPS Line Leaders & Operators items (PP, TAT, WIP & other items) on Line Mieruka board

Date : Mar'12
Participants : All LSPS LineLeaders & Operators

61

APPENDIX 13: KANBAN

LINEAR LEAN PROJECT

Completed
In Progress
Planned

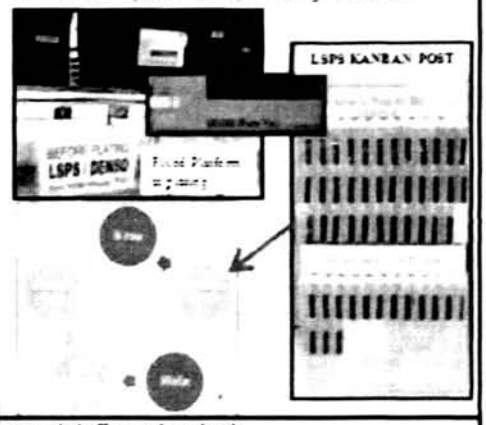
Title: Kw Reduction at Plating	Operation/ Machine:	MUDA Category:	Done by / Date:
	Plating	Waiting	Teh KH/ Feb 12

Before :

1. High WIP (sometimes @ 3 days stocks
2. Push System (Must opt push lots to plating
3. No Control of WIP
4. No Fixed Location
5. No FIFO

After :

1. Fixed Location for LSPS stocks 3 platforms
2. Kanban System (X-Ray ~ Plating ~ Mark Out



Problem & Impact : (Jan'12)

1. Avg Kt at Plating : @ 42 hrs
2. Avg daily WIP at plating : @ 100 kpcs

Result/Effect : (Mar'12)

1. Avg Kt @24 hrs reduced by 38%
2. Fix daily WIP at plating @60kpcs reduced 40%

APPENDIX 14: FIRST-IN-FIRST-OUT

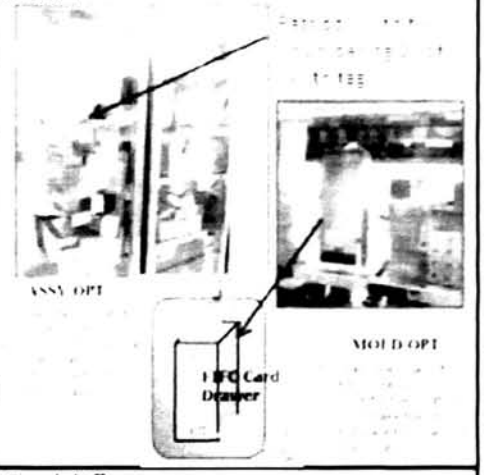
LINEAR LEAN PROJECT

Completed
In Progress
Planned

Title:	Operation/ Machine:	MUDA Category:	Done by / Date:
FIFO System at Pass Box	ASSY / MOLD	Waiting	KhorPL / Mar 12

Before :

After :



Problem & Impact :

1. No FIFO practice at pass box.
2. Molding L2 has to search for the lot.

Result/Effect :

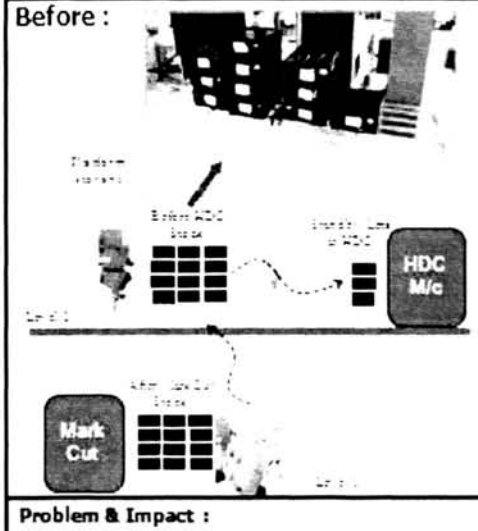
1. FIFO system is practised
2. Short lead time

LINEAR LEAN PROJECT

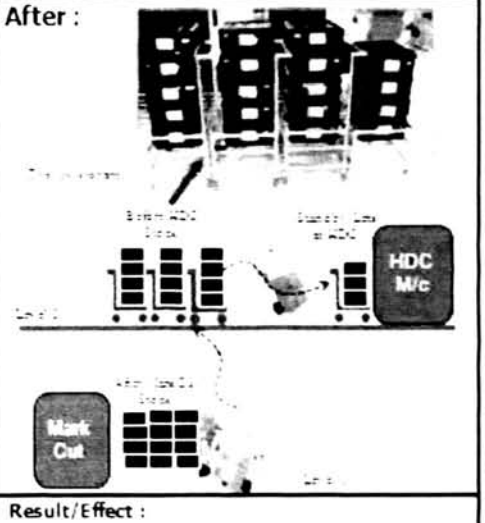
Completed
In Progress
Planned

Title:	Operation/ Machine:	MUDA Category:	Done by / Date:
New Storage & FIFO at HDC & RDC	HDC / RDC	Transportation	Mar 12

Before :



After :



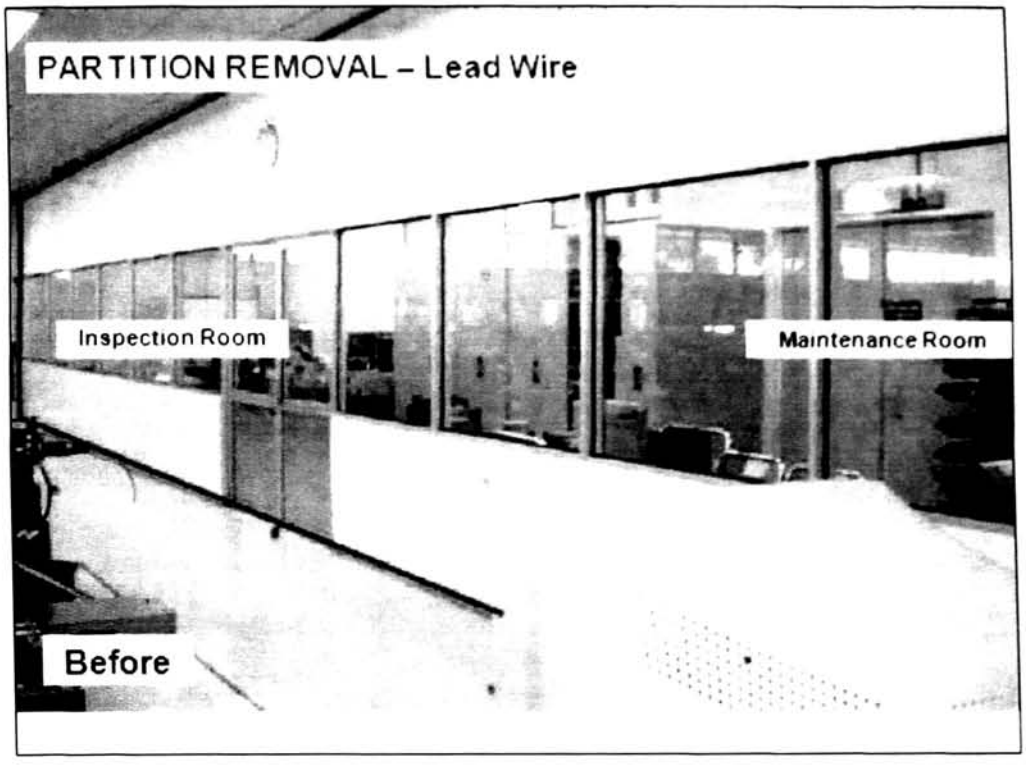
Problem & Impact :

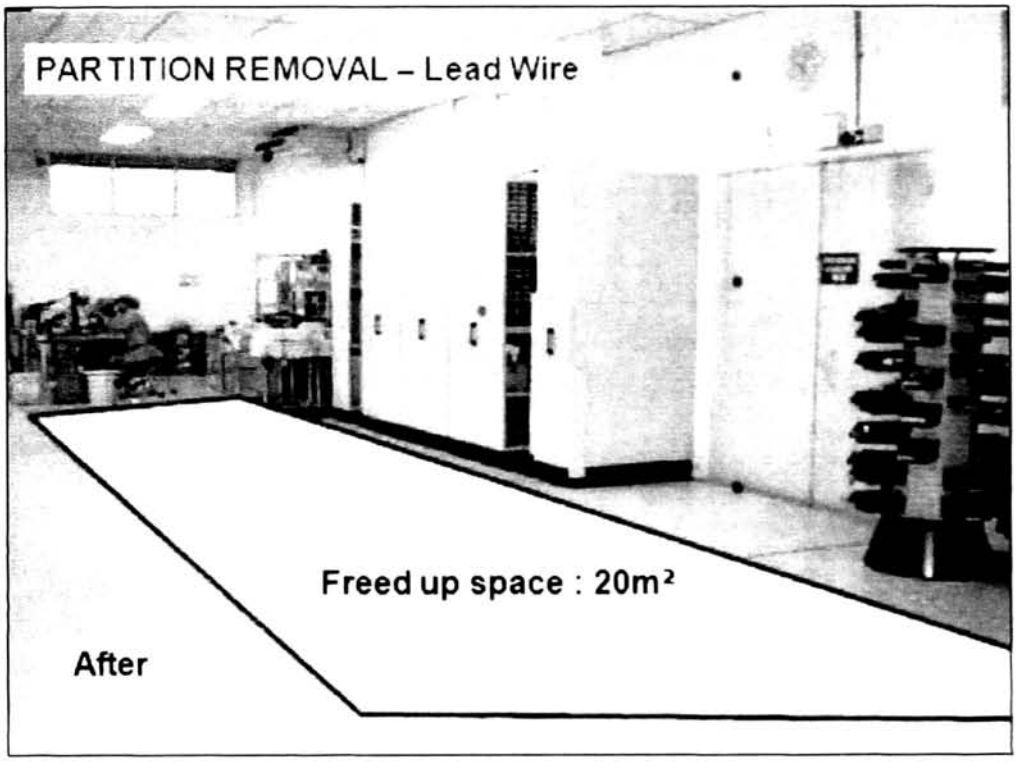
1. Difficulty to practise FIFO at HDC.
2. Lots of transportation (platform to platform).

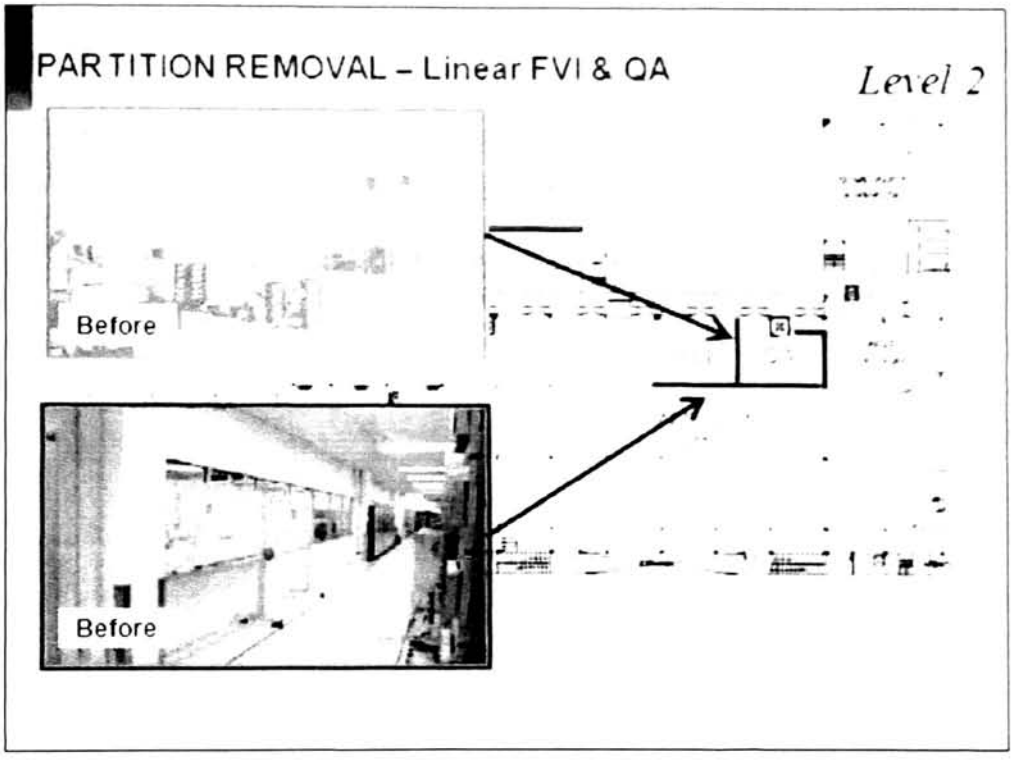
Result/Effect :

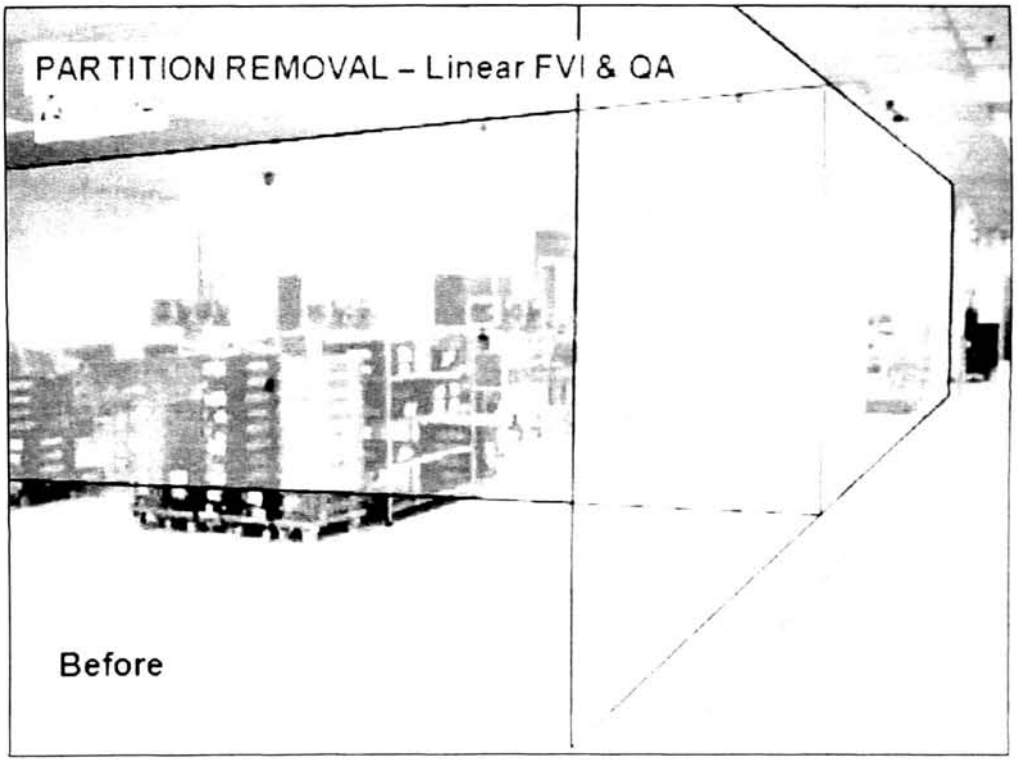
1. FIFO (by batch of trolley)
2. Reduce Muda of transportation (storage to mixing)

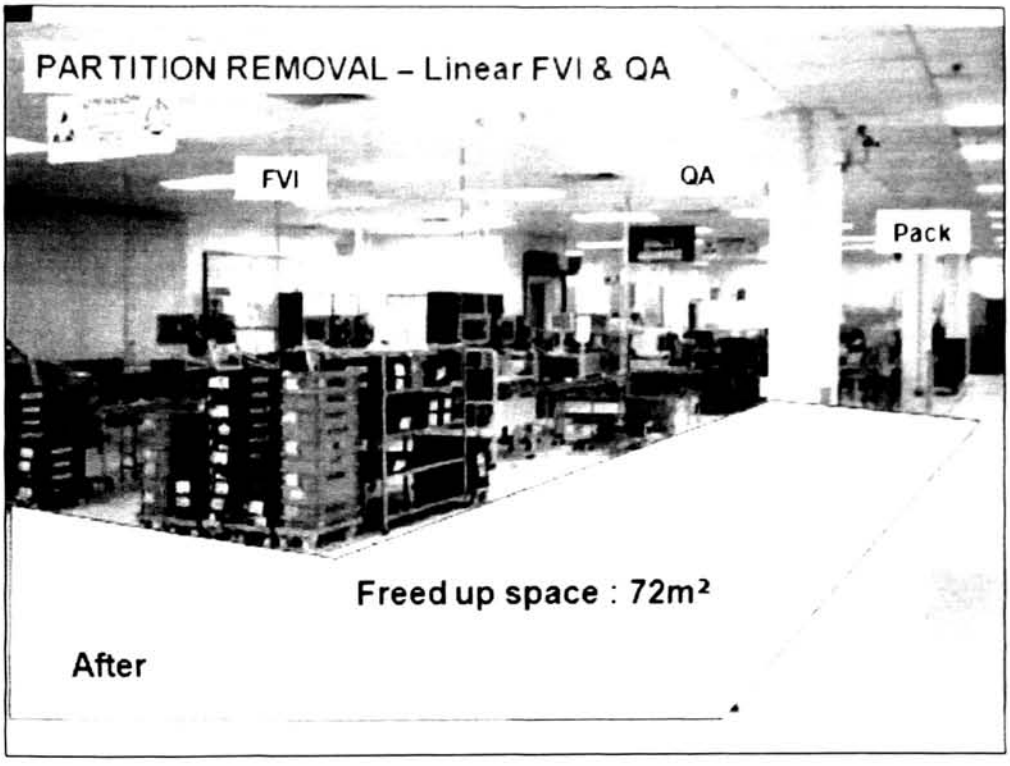
APPENDIX 15: PARTITION REMOVAL






PARTITION REMOVAL – Linear FVI & QA
Level 2
Before
Before


PARTITION REMOVAL – Linear FVI & QA
Before


PARTITION REMOVAL – Linear FVI & QA
FVI
QA
Pack
Freed up space : 72m²
After

APPENDIX 16: KAIZEN INNOVATIVE TEAM

1.1 LINE LEADER TRAINING SESSION

Training

Training sessions for Line Leaders - 14 Feb & 6 Mar

Total Participants
- 14 Feb - 24
- 6 Mar - 23

Response

Good response and participation from all participants

Training Contents

Module 1 : Basic Concept
- History OF SGA
- What is SGA?
- Objective
- What are the activities for SGA ?
- Benefit
- Key success factor for SGA

Module 2 : Roles & Responsibilities
- Team Formation
- Selecting a leader
- Team Conduct
- Group Meeting
- Suggestion & problem escalation
- Outing
- Project Follow up

Module 3 : Problem Solving Tools
- PDCA Cycle
- Brainstorming
- The 7-QCC Tools
- 5-Why
- 7-Waste

Module 4 : Presentation
- The needs of presentation
- Presentation Structure

Module 5 : Documentation
- Group Registration
- Meeting/Outing Registration
- Claim
- Project Tracker

1. TRAINING

Training

Enhance knowledge and understanding of SGA as well as knowledge of basic problem solving tools.

Action :

1.1 Review/Enhance SGA Handbook

1.2 Provide "Back-To-Basics (B2B)" training to all level of SGA members

1.3 Train selected trainers for sustainability.

1.4 Compulsory training for group leaders and opts/techs with more than 1 year service.