Faculdade de Engenharia da Universidade do Porto
Mestrado Integrado em Engenharia Industrial e Gestão

Critical Factors of Lean Implementation in Manufacturing Environments

Victor Simões

Dissertação do MIEIG 2007/2008
Orientador na FEUP: Prof. Américo Azevedo

Setembro de 2008

Dedico este trabalho ao meu filho Gabriel

Abstract   Although Lean is certainly not a new concept, it is doubtless still relevant, being one of the most promoted and competitive management models in use today. Many companies have adopted the Lean Culture with success but a large number has failed when attempting this goal. As companies try to implement and apply Lean in response to competitive pressures, they often become one-dimensional in their approach. As the main purpose, this document seeks to study and analyse the underlying reasons surrounding companies' failures in their Lean initiatives and how to implement them in a successful and sustainable way. This document is based on a thorough literature research concerning the success and failure of Lean implementations, enriched through an assortment of individual interviews with Lean experts, acting as a precursor for the development of a novel roadmap as a practical guide to open up a window of opportunity for managers, who want to become Lean in an effective and sustainable way.

CONTENTS

LIST OF TABLES AND FIGURES

Tables

Figures

1. INTRODUCTION

1.1 Context

Markets are changing rapidly with customers demanding manufacturers to provide high-quality and variability products at substantially lower prices. Furthermore, cost pressures caused by energy, materials, labour costs and many other factors continue to increase.

Meeting the challenges of worldwide competition in manufacturing or services requires now operating policies, practices and systems that eliminate waste and create competitive value for the end-use customers. It is also a crucial tactic and requirement for manufacturing companies, in the 21st century, recognise the need of operational flexibility and managing time performance (by shortening the new product development cycle and trimming process time in the factory) to improve and gain a competitive advantage that is a constantly moving target in today's turbulent environment.

In pursuing the competitiveness goal, many companies have been adopting one or more of a growing number of improvement programs, starting with TPS (Toyota Production System), TQM (Total Quality Management), JIT (Just-in-Time) production, TPM (Total Productive Maintenance), not to mention reengineering and benchmarking, leading the way into a new approach to operations that formed the basis of what we now know as Lean Thinking.

The term "Lean Thinking" was first coined in 1996 in the book *Lean Thinking* by JP Womack and Jones, becoming internationally recognised. The book followed-on another one, *The Machine That Changed the Word* (1990). Both explored the Toyota system experience in Japan, just-in-time manufacturing and reducing non-value-added activities. Womack suggests using the term Lean to refer to the philosophy that focuses on eliminating waste and improving value for clients.

The Toyota production system was born after World War II, having *Taichii Ohno* as its mentor. While Ford and GM used mass production, economies of scale and big equipment to produce many parts as possible and as cheaply as possible, Toyota's market in post-war Japan was small and therefore compelled to make many types of vehicles, in small quantities with the same manufacturing processes to satisfy its customers. By emphasising on just-in-time production and total quality control, making lead times reduction and keeping production lines flexible, the Toyota system gave to many Japanese manufacturers who adopted it in the mid-1970s a distinct competitive advantage, compared to the U.S and European ones.

Although the Lean concept is intrinsically connected to Toyota system, the genesis of Lean principles can be traced back to Henry Ford (in the early 1900s). Ford changed the handcraft industry paradigms and developed many techniques that today would be associated with Lean. He managed to link consistently interchangeable parts with standard work and moving conveyance, which made the moving assembly line possible, to create the basic premise for what we now call a continuous flow production system (James P. Womack & Daniel T. Jones, 1996 / 2003).

But this benefit to the manufacturing process came, hand-in-hand, with a major drawback. Paraphrasing Marx's commentary on capitalism, mass production contained the seeds of its own destruction. In a world where changes in market demands and technology advances come quickly, mass production seemed to lose its way. Emphasising the manufacturing based on long runs and high volume production due to the high cost of disruption of the process, and keeping on adding inventories to buffer different stages, both from each other and from the erratic behaviour of suppliers and customers – to assure smooth production, was no longer the solution.

Therefore one can conclude that the Lean concept as it is known today evolved purposefully over time. It borrowed key concepts and practices, developed by Henry Ford and was afterwards driven forward in alignment with Toyota's corporate purpose, based on key principles and a *kaizen* culture. It goes far beyond just waste elimination. It aligns how an organisation thinks and works (Flinchbaugh and Carlino, 2006). By implementing Lean principles and practices, companies can achieve many beneficial results, including: higher quality products and services, increased market share, margin expansion, revenue growth, higher productivity, better customer focus, faster response to changing market conditions and higher asset efficiency.

Over the past 20 years, Lean has gained significant exposure with many companies around the globe adopting Lean methods in many forms and by many names. Today, it is still being one of the most promoted and competitive management models in use. The current intense interest in Lean represents the industrial and service company's validation of its applicability.

However and as stated by Jerry Kilpatrick and R. Osborne (2006) "the bad news is that even the trend of Lean adoption continues, the success rate is low – less than 20% of companies are successful with Lean". The data indicate that there are many obstacles and that most companies have great difficulty implementing Lean principles and practices, despite the best practices available and the extensive materials on technical details of Lean.

In fact, while thousands of companies worldwide have been engaged in the Lean transformation for a long time, most have achieved only modest levels of improvement and impact results, despite years of effort. According to John Drew, B. McCallum and S. Roggenhofer (2004, p. XV) "these days, it seems that most industrial enterprises and many service companies claim to apply Lean thinking in their operations. Many of them do indeed apply Lean tools, but few managed to reap the benefits that Toyota and others have achieved". Their ability to achieve a Lean transformation across the enterprise is severely limited by the implementation process normally used by companies and often advocated by consultants (Cynthia Swank, 2003). The problem tends to be probably more related to how Lean is deployed, rather than its applicability (Monica W. Tracey and Jamie Flinchbaugh, 2006).

These conflicting results are leading to frustration, confusion and a growing debate about whether the difficulties with these efforts are the result of poor management or a lack of knowledge and understanding of the concepts themselves.

1.2 Research Questions

To address some of the problems mentioned above, the research presented in this document aims to investigate the following questions:

- Why do so many companies fail in their Lean initiatives?
- How to perform a Lean implementation in a successful and sustainable way?

In addressing these questions it is pretend, first to study and analyse the underlying reasons surrounding companies' failures when attempting their Lean initiatives and second, to examine how the companies' different approaches when implementing Lean, make a difference in terms of performance impact and sustainability.

1.3 The Research Methodology

In order to meet the aims and objectives of the study, two main data sources and methods have been employed: a literature review and personal interviews analysis. This section outlines the data sources and the research methods used.

A. Research Plan Design

The research project approach is largely inspired in Yin's methodology, which assumes the following aspects:

i)   critical review of the literature in order to formulate theoretical propositions regarding the research topic (i.e. understandings taken from it);

ii)   validation of the theoretical propositions through analysis of the particular data collected findings (interviews).

Figure 1: Research Plan Design (Adapted from unpublished source)

B. Literature Review

A systematic literature review was carried out to provide a critical review of the available literature. Systematic reviews took a defined sequence of locating, analysing, ordering and evaluating literature from defined sources within a given frame. A total of 45 sources of data were reviewed, summarised and analysed. These comprised mainly:

- Books, journal articles, including peer-reviewed articles
- Unpublished articles, papers and reports from current and previous research projects
- Websites of professional institutes and consultancies

The literature review was carried out between March – June 2008.

C. Data Collected Research: Personal Interviews

A study was undertaken through the realisation of personal interviews with a restricted group of people who have been engaged with carrying out Lean projects in manufacturing environments. The profiles of those interviewed varied from Management Consultants and Academics to Lean Managers, to ensure a broad representation of perspectives. Available resources limited the number of interviews the researcher could conduct.

A semi-structured interview pro-forma was designed and prepared, which was divided into key topic headings, with key questions to be asked (see Appendix 2). The purpose was to obtain additional information (and incorporate it into the research evidence) of the following aspects of the application of Lean: (1) What factors made the sites suitable for successful application?; (2) What factors are relevant to the development of organisation readiness for Lean?; (3) Which tools and techniques within the domain of Lean have been used and which were seen to work?; (4) What types of problems / issues were being tackled by the Lean initiatives?; (5) What lessons are there for successful implementation?

The interviews were conducted during July and August 2008.

1.4 Outline of the Research Work

The study is organised and structured around the following steps:

1st: Identify the major difficulties companies encounter in attempting to implement and apply Lean, through a Lean journey; 2nd: Conduct a research study, through an assortment of personal interviews, in order to validate and complement the theoretical results; 3rd: Provide a roadmap to Lean implementation towards a successful and sustainable way.

In this context, the document is divided into five chapters.

- *Chapter 1, Introduction,* presents Lean origins and its evolutional context. Introduces the research aims / objectives of the study, and sets out the data and information sources, the methods of data collection and the analysis employed.

- *Chapter 2, Lean (Literature Review),* presents the various views from practitioners in terms of the evolutional concept of Lean, its definition, approach and elements, towards a working basis proposal for use in this thesis. It also outlines the associated Lean outcomes, both the tangible and intangible, focusing particularly on their relevance to the manufacturing environment. This chapter ends with a survey of the

main critics to Lean, found also in literature.

- *Chapter 3, Critical Success Factors for the Implementation of Lean,* presents an identification proposal of the critical success factors in Lean implementation processes. This identification is based on a comprehensive and fully detailed analysis, of the practical difficulties /barriers that led to failure in the implementation of changes, as well as factors that support sustainability.

- *Chapter 4, Towards a Lean Enterprise-Wide Transformation,* presents and describes a methodology through the construction of a novel roadmap for transitioning an existing manufacturing system to one that fully implements the Lean condition.

- *Chapter 5, Conclusions,* summarises the key findings in reference to the success factors and difficulties / barriers in implementing Lean. This chapter outlines also the limitations of the research study approach and reflects on the potential future directions for future work.

2. LEAN (LITERATURE REVIEW)

Much has been said and written about Lean and its application. Since 2000 there has been an exponential rise in the literature on this subject. However a lot of misinformation and confusion exists regarding Lean concept and its definition, exhibiting a limited understanding of what contemporary Lean approaches are really about.

It is the purpose in this chapter and through a literature review, to increase and clarify the understanding of the Lean evolutional concept and philosophy, towards a working basis proposal for further use in this thesis. Furthermore, this chapter will also approach the potential benefits of Lean and the Lean enterprise with a focus on internal manufacturing process and external networks, ending with a survey of the main critics to Lean, also found in literature.

2.1 Concept (Evolution)

Lean as a concept has undergone a significant evolution and expansion beyond its origins in the auto industry and its narrow definition around shop-floor improvement. In fact, Lean operations management design approach focused on the elimination of waste showed localised impact only, and fell short on its intended impact on the overall system's performance.

In 1996, a new design based upon "Lean principles" (Womack and Jones) had moved the Lean concept from a merely "shop-floor-focus" on waste and cost reduction to an approach creating and enhancing value to customers by adding product or service features and/or eliminating wasteful activities. This was a key development and gives Lean another dimension, as it started to be focus on the value perceived by the ultimate customer, with value having its true meaning when expressed in terms of a specific product or service, with specific capabilities, meeting the customer's needs at a specific price and time (Womack and Jones, 2003). Therefore and regardless of whether any activity appeared to be wasteful from a shop-floor point of view or to be costly, it is the customer that ultimately decides what constitutes waste (*muda*) and what does not. As such, value creation must be seen more than just a cost reduction.

Figure 2, shows the relation between value and cost of products or services and the correlative cost-value perception by the customer. The cost-value equilibrium line indicates a situation whereby the perceived customer value provided by a product or service, corresponds exactly

to its costs. The further above the cost-value equilibrium line a product/service can be positioned, the more attractive it is the proposition to the customers.
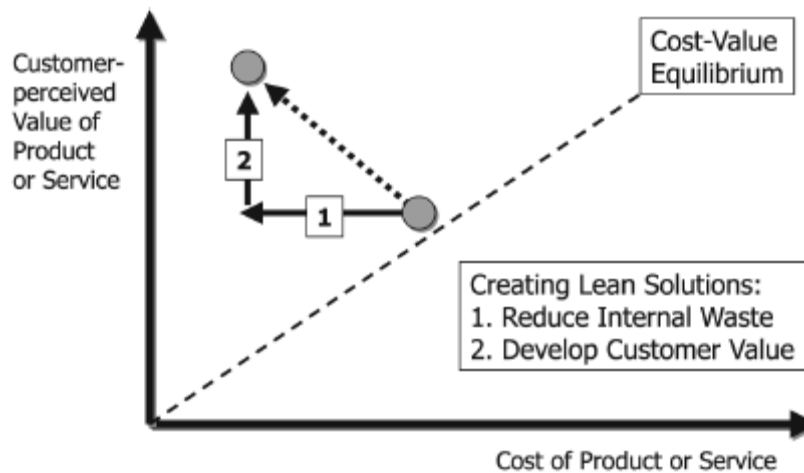
Figure 2: The relation of value, cost and waste (Source: Peter Hines, *et al.***, 2004)**

This changed perspective from a mere waste reduction focus to a complementary customer value focus, provides a new dimension in what value creation is concerned:

- Value is created as the internal waste and associated costs are reduced, increasing therefore the overall proposition for the customer;

- But value can be also increased, by developing and offering additional features or services without incurring in additional costs, yet valued by the customer.

Lean, driven by the value creation framework just outlined with the focus on the final customer, explores the value proposition at a strategic level whereby understanding value is fundamental. This goes beyond than just waste elimination. As a result of this development, and in order to avoid confusion about what is Lean and what is not, Peter Hines *et al.* (2004), encourages the existence of Lean at two levels, strategic and operational, with the consequent distinction use of Lean thinking and Lean production. The use of Lean production for the shop-floor tools application and Lean thinking for the strategic value chain dimension. Sustaining Lean production at an operational level and Lean thinking at a strategic level, in a complementary way, is vital to understand Lean as whole and avoid confusion and misunderstanding, about where to apply the right tools and strategies to provide customer value.

2.2 Lean Philosophy

Lean is not a project, but an ongoing quest for perfection through the elimination of all sources of loss (John Drew, *et al.*, 2004). Taken to its fullest extent, Lean is as much about operational excellence as a strategy approach. In this context, Lean should be viewed more as a business philosophy than a merely set of tools or techniques just to improve operations (Moore, 2001). For that, alongside manufacturing, all other subsystems need to change if an organisation wants to convert into a Lean, learning enterprise, reaping its full benefits. Liker (2003) insists that the right combination for it consists of a long-term philosophy, processes and people with a culture all about competitive excellence. It is important to introduce an alignment in the ways the members of an organisation think and behave.

K. Bozdogan (2006) outlined a set of mutually-reinforcing "tenets" reflecting an updated view of a Lean enterprise:

- Focus on the customer, making sure that the customer needs and expectations act as a pull on all enterprise activities;

- Eliminate all sources of loss with the goal of creating value throughout the enterprise value stream, on a sustained basis in both the short-run and long-run, by concentrating on delivering best lifecycle value as defined by the customer;

- Pursue knowledge-driven enterprise transformation, optimizing people's capabilities and making optimal use of them to achieve the evolutionary enterprise-wide change;

- Foster a dynamic process of change and capability-building to ensure the creation of a robust, adaptive, flexible and responsive enterprise that can withstand failure in specific enterprise elements, adapt to external shifts and respond quickly to changing market conditions and technological advances, with the goal of evolving a sustained competitive advantage.

This reflects the recognition that a Lean transformation needs to be seen as a journey, and not as a tactical or technical process (Bhasin and Burcher, 2006; John Drew *et al.*, 2004), which happens incorrectly all too often, betraying a deep misunderstanding of the scale and nature of the challenge.

Although Lean does yield immediate results, the full benefits come only when it becomes the basis for a process of continuous improvement able to keep the results over time. Such a view implicates a mental shift away from the short-term focus to a long-term perspective. Companies need to institutionalise Lean practices and their policies deployment as part of

their capability-building. Sustaining such a long-term management philosophy presents the challenge for the companies embarking on a Lean journey.

According to Peter Hines *et al.* (2008), to develop an effective and sustainable Lean transformation change, companies need to address each of the following elements, at all levels of the organisation: strategy & alignment, leadership, behaviour & engagement, process management and technology, tools & techniques. This perception is reiterated by John Drew *et al.* (2004) arguing that Lean requires simultaneously the integration of three elements: operating system, management infrastructure and mindsets and behaviours. According to them:

- The operating system lies at the heart of a Lean company. More than a system execution, it is the way resources and tools are driven and managed by an organisation in order to create value to the customer and minimise the sources of loss that can occur;

- The management infrastructure consists of the organisation structure, processes and systems required to support and sustain the operating system and ensure the performance objectives;

- Mindsets and behaviours represent the ways of thinking and acting at all levels of the organisation. It's the organisational culture required to engage a Lean journey.

Moreover, the Lean excellence model uses a holistic approach for managing and improving operations of the organisation. Instead of optimising just individual parts or processes, it seeks to improve the system as a whole.

2.3 Benefits of Implementing Lean

A sizeable portion of literature dwells on the apparent empirical evidence suggesting that Lean aids competitiveness. Lean is often associated with benefits such as reduced inventory, reduced manufacture times, increased quality, increased flexibility and increased customer satisfaction. The Engineering Employers Federation (2001) - EEF, investigation on US and UK productivity, found a clear link between Lean adoption principles and higher productivity and profitability.

Based on years of investigation, Womack and Jones (2003), reports the following "rough" improvements from converting to Lean:

	INITIAL LEAN CONVERSION	CONTINUOUS IMPROVEMENT
LABOR PRODUCTIVITY	Double	Double again
PRODUCTION THROUGHPUT TIMES	90% Reduction	50% Reduction
INVENTORIES (THROUGHOUT)	90% Reduction	50% Reduction
ERRORS REACHING THE CUSTOMER	50% Reduction	50% Reduction
SCRAP	50% Reduction	50% Reduction
TIME-TO-MARKET (NEW PRODUCT)	50% Reduction	50% Reduction

Table 1: Improvements from converting to Lean

Values in the "Initial Lean Conversion" column are the results that can be expected from the initial conversion effort, with the "radical" realignment of the value stream. Values in the "Continuous Improvement" column are the further improvements that can be expected a long time from continuous improvement efforts on a sustainable basis.

Kirk Bozdogan *et al.* (2000), from the Massachusetts Institute of Technology – MIT, argue that from transitioning to a Lean enterprise, "benefits accrue both in factory operations and in areas beyond the production floor".

In fact, the benefits of implementing Lean can be broken down into three broad categories: operational, organisational and strategic improvements (Jerry Kilpatrick, 2003). Even to this day, most organisations implement Lean just for operational improvements, basically because of the perception that Lean only applies to the operations side of the business. However reported studies concluded that organisational and strategic benefits generated by the adoption of Lean principles and practices are equally important.

Operational Improvements

According to Lean Enterprise Institute (www.lean.org) factories that convert to Lean production can expect the following typical results:

- Lead Time (Cycle Time) reduced by 70 to 90%

- Productivity increased by 20 to 30%

- Work-In-Process Inventory reduced by 80%

- Quality improved – defects reduction by 90%

- Total floor space utilization reduced by 40%

Organisational Improvements

A Lean implementation provides not only operational and economic benefits to the organisation, but also other less tangible benefits as well. The organisational structure shifts from a vertical to a horizontal focus, aligning value-adding activities with the customer value-stream (Peter Hines *et al.*, 2008). Process focus takes priority over the functional focus. Communication is increased with information flowing across functional boundaries (J.M. Morley & T.L. Doolen, 2006; Monica Tracey & J. Flinchbaugh, 2006). Decision-making process is decentralised contributing to enterprise responsiveness (Kirk Bozdogan *et al.*, 2000). The organisation becomes flattened reducing overhead.

Strategic Improvements

Many companies who implement Lean do not adequately take advantage of the improvements. A recent study conducted by the Aberdeen Group shows that 66% of companies believed that "cost reduction in manufacturing and the supply chain" was the key target for a Lean initiative (Jerry K. & Robert O., 2006) – (see Figure 3).

Lean is being viewed primarily as a cost-reduction priority and not as a market domination strategy, as it should. However if companies shift their focus to growth-oriented targets, they will quickly realize that improved operating margins and increased flexibility generated by the adoption of Lean, provide enhanced business opportunities in existing markets or new ones, with potential higher profitability and revenue results.
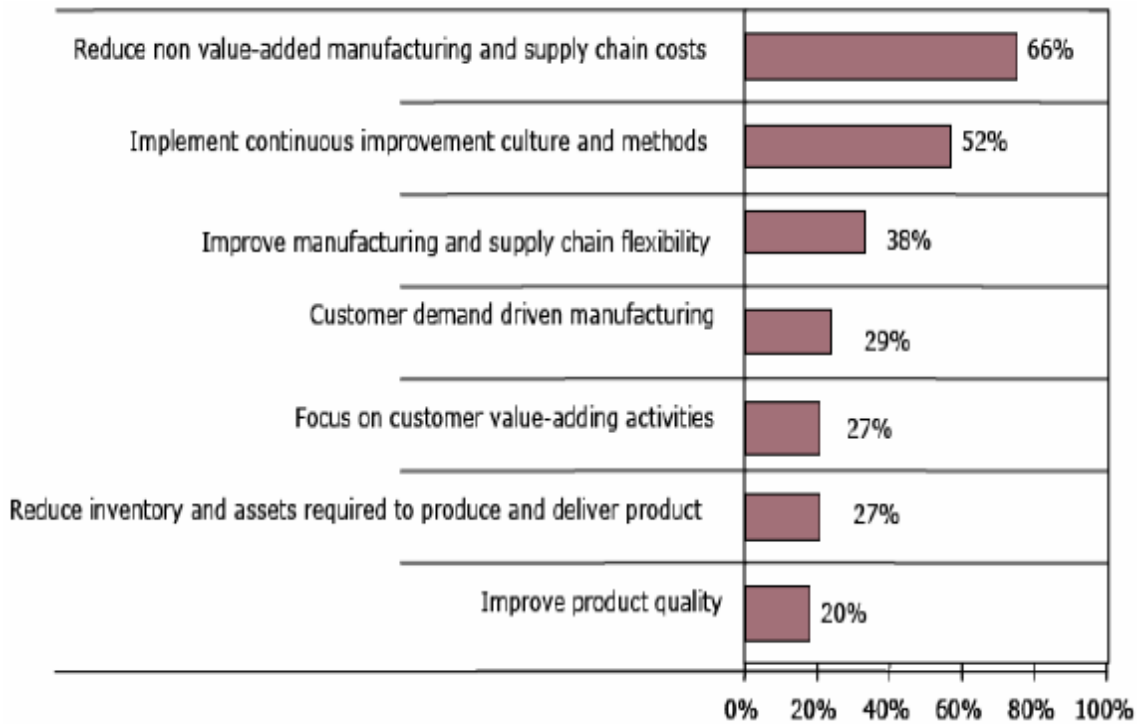
Figure 3: Best-in-class Strategic Actions (Source: Aberdeen Group, March 2006)

2.4 The Lean Enterprise

2.4.1   Focus on the Internal Manufacturing Process

Lean production is distinctly different from conventional manufacturing. Lean production is built around the concept of continuous-flow processing – a departure from traditional, "or push", manufacturing systems, in which large batches are processed at each step and are passed along only after an entire batch has been processed. The majority of current systems are yet batch-and-queue, task-oriented and functionally isolated. Usually they are designed and arranged as separate system elements, which result in excessive inventory requirements and parts travel time and distance.

On the contrary, Lean manufacturing is structured to ensure value stream flow, where possible, and support one-piece flow and just-in-time (pull) production. Moreover, with an approach that eliminates waste by reducing costs in the overall production process, through continuous improvement (Womack and Jones, 2003).

The Lean production system is therefore supported by simple methods and tools to eliminate non-value added operations and activities and consistently deliver the value that customers

seek in the products and services they buy. The intent of these methods and tools is to simplify work and the workplace, improve quality, reduce lead-time and focus people on performing only those activities that create value.

Five primary elements are required to support the manufacturing component of Lean production: (1) Manufacturing Flow, (2) Organisation, (3) Process Control, (4) Metrics and (5) Logistics (Feld, William M., 2001).

Manufacturing flow concerns the physical changes and design standards deployed as part of each work cell. *Organisation* establishes people's roles and functions and trains them in news ways of working and communicating. *Process control* includes efforts to monitor, control, stabilize and improve the manufacturing process. *Metrics* involves establishing visible results based on performance measures, determining targets for improvement and work teams recognition for their process improvements. *Logistics* defines the operating rules and mechanisms for planning and control the flow of material. Figure 4 indicates the basic tools and methods to satisfy the requirements of each of these five Lean manufacturing elements.

MANUFACTURING FLOW	ORGANIZATION	PROCESS CONTROL
1. Product/quantity assessment (product group)	1. Product-focused, multi-discplined team	1. Total productive maintenance
2. Process mapping	2. Lean manager development	2. Poka-yoke
3. Routing analysis (process, work, content, volume)	3. Touch labor cross-training skill matrix	3. SMED
4. Takt calculations	4. Training (lean awareness, cell control, metrics, SPC, continuous improvement)	4. Graphical work instructions
5. Workload balancing		5. Visual control
6. Kanban sizing		6. Continuous improvement
7. Cell layout	5. Communication plan	7. Line stop
8. Standard work	6. Roles and repsonsibilities	8. SPC
9. One-piece flow		9. 5S housekeeping
METRICS	LOGISTICS	
1. On-time delivery	1. Forward plan	
2. Process lead-time	2. Mix-model manufacturing	
3. Total cost	3. Level loading	*SOURCE: Feld, William M. Lean Manufacturing: Tools, Techniques, and How To Use Them. St. Lucie Press, 2001, p. 5*
4. Quality yield	4. Workable work	
5. Inventory (turns)	5. Kanban pull signal	
6. Space utilization	6. A, B, C parts handling	
7. Travel distance	7. Service cell agreements	
8. Productivity	8. Customer/supplier alignment	
	9. Operational rules	

Figure 4: Five primary elements of Lean manufacturing

2.4.2   Focus on the Organised External Networks

Womack and Jones (1994) have developed the Lean enterprise view further. They envisaged it as "a group of individuals, functions, and legally separate but operationally synchronized

companies". Underlay to this idea is the linkage of individual companies, in terms of Lean principles and practices, up and down the value chain to form a continuous value stream, structured and optimised. Therefore being the companies global, operating in networks and building knowledge structures together with other actors (Karlsson, 1992).

Thus, the Lean enterprise view must also focus on the external networks of the firm. In what must be built outside the manufacturing process in terms of Lean procurement, Lean distribution and the partner strategy of the firm – Figure 5 (Karlsson and Ahlstrom, 1997).

Lean procurement consists in exploring the organized networks of suppliers and their knowledge input from a strategic alliance perspective. Develop long-term supplier relations moving toward cooperation synergy so these networks can provide their specialized knowledge into the development and transformation process of the local firm.
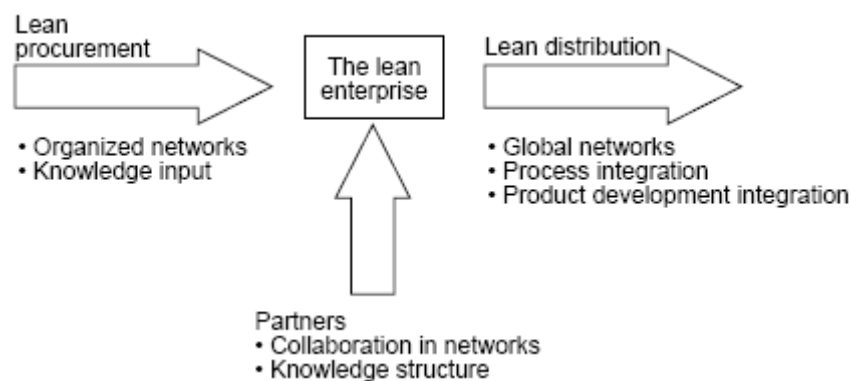
Figure 5: The Lean enterprise (Source: Karlsson and Ahlstrom, 1997)

Similarly, it will likely be necessary to develop Lean distribution based on the departure principle that the firm is a part of a global network. Important in this network is process integration and product development integration. By process integration one means production against customer orders, only made possible through the implementation of Lean manufacturing methods and techniques, mentioned above.

Through the product development integration principle, customer viewpoints are integrated directly into the product development function, in order that single products are not developed in isolation and are seen as part of a coherent product strategy aligned with internal and external customer requirements (Peter Hines *et al.*, 2006).

Finally, the Lean enterprise must rely strongly on partners. It must stress the use of

partnerships and the principle of collaborating in networks with specialists in different areas, including competitors. The purpose is to increase the specialist competence of the firm (Womack and Jones, 1994).

2.5 Criticism of Lean

Lean has been criticised over time, with critics from within and outside the Lean movement. Various gaps have been pointed out. Among them, literature refers the lack of human aspects consideration, the lack of strategic perspective and ability to cope with variability, and the narrow operational focus on the shop-floor, as the main negative points of view.

Human aspects

The most outspoken critics highlight the stressful effects that the Lean production systems had on the work life of production workers. Papadopoulou and Ozbayrak (2005) refers to an EPSRC funded project at Cambridge University (2003) indicating that Lean production results in elevated stress levels and therefore increased worker turnover and absenteeism with impact on manufacturing performance. Further support to this argument is the point of view of Landsbergis and Cahill (1999) by finding little evidence to support the hypothesis that manufacturing workers are empowered under Lean production. In fact, auto-industry studies suggest that Lean production creates intensified work pace and demands.

Although such authors have failed to gain widespread support for their views, they have indeed raised an important point – the human factor orientation through motivation, empowerment and respect, i.e. the Lean enterprise is beyond doubt (MIT, 2000).

Lack of strategic perspective

Underlay to this criticism is the almost complete lack of discussion of strategic level thinking in Lean programmes. The more common approaches to Lean are mostly focus on manufacturing and operational process which exhibits a limited understanding of the transition process required to bridge from the present status to the future one. This gap has led to a lack of sustainability of many Lean transformation programmes.

Coping with variability

Another focal point of the criticism is the ability of Lean production systems and supply chains to cope with variability. Seasonality, variability in demand and fluctuations in supply and associated lead times are not easily captured or measured in a value stream map

(Kilpatrick and Osborne, 2006). In discussions of values streams and value chains, there is often an underlying assumption of perfect congruence of the value systems of all the stakeholders and enterprises that are linked together to deliver value to the customers.

However in the real world, asymmetrical power relationships and the fact that any given enterprise may be embedded in multiple value streams with their respective pulls, may not result in such perfect harmony. It is a fact that in order to add value to the customer the Lean approach has had to develop new ways to manage variability and capacity, such as mixed model scheduling and production levelling or smoothing. But this is hardly the answer for today's super-fast response industrial world with is highly variable market environment. As a result it should be noted that several attempts have been made so far in investigating more agile solutions with a greater emphasis on dealing with customer demand variability, flexible assemble-to-order systems, creating virtual supply chains and greater use of IT tools.

2.6 Synthesis

In this chapter, Lean and its evolution overtime has been reviewed. Lean is one of the most influential new paradigms in manufacturing, and as a concept it has expanded beyond its origins in the auto industry, from its narrow definition around shop-floor improvement to a strategic value proposition. The resulting Lean value system encompasses a value-adding network of operations across companies, with the goal of providing a series of contingent value proposition to individual final consumers.

This chapter has led also to a better understanding of what constitutes Lean and what does not, as well as the expected outcomes that range, from short-term operational tangible targets to broad organisational improvement and culture change.

It has been also acknowledge the key criticisms associated with the gaps in the Lean philosophy. These includes: concerns about the increased vulnerability of Lean systems to errors or resource shortages; suggestions that Lean systems do not cope well with demand variability; potential failure to address human dimensions of work content and work environment; and a lack of strategic perspective when implementing Lean tools and techniques.

3. CRITICAL SUCCESS FACTORS FOR THE IMPLEMENTATION OF LEAN

Research demonstrates that not all Lean projects succeed as they should, and that there can be practical difficulties in applying these principles. Many of the reasons can be traced back to decisions, omissions and problems that occurred prior to the start of the improvement process.

This chapter presents an identification proposal of what is considered to be the critical success factors in a Lean implementation process. This identification is based on a comprehensive and fully detailed analysis of the Lean failure reasons found in literature research studies. An empirical investigation, achieved through an assortment of interviews with Lean experts, is then presented and discussed in terms of the identified outcomes and key factors. Upon this combination approach the study answers fully to the first topic research question of this paper and partially to the second one.

3.1 Lean Challenges

Case studies of companies that have tried to adopt the concepts and implement them in their own management systems, have proven that the transition process is an arduous and time-consuming task and can even be somehow problematic in some cases.

The majority of the researchers acknowledge that the transformation process to a Lean management system across the enterprise requires a lot of effort, participation of all levels in the organisation hierarchy, introduction of new principles not only in the shop-floor level but also in the company culture and in the organisational structure. For these reasons, transition can be a slow, incremental, complex and stressful process that might bring along a great degree of uncertainty as there are no clear guidelines for the transition; rather more the process differs substantially from case to case (Papadopoulou and Ozbayrak, 2005). Transforming an organisation to a Lean enterprise is a dynamic process and unique to each organisation.

Furthermore and in general the current level of knowledge possessed by the people leading and participating in a Lean transformation is limited, often missing the intents and nuances of "real Lean" such as: (1) Lean is oriented to be a stakeholder-based system of management and not a management practice that promotes individual shareholders benefits in detriment of all other shareholders; (2) negative cutting, such as layoffs, is not the intent of Lean. Instead, it should provide a way to create new work, motivate and develop workers full potential, rather than simply destroying jobs in the name of efficiency, in order to create stable and long-term

growth; (3) the principles of Lean management can be applied to every business process; (4) the "continuous improvement" and "respect for people" principles are the key to making the Lean management system work (Emiliani and Stec, 2005). Because these points are not widely shared and understood among Lean management practitioners, it is foreseeable that associates or other key stakeholders, such as suppliers, customers, or investors will experience negative outcomes.

3.2 Focus on Lean Failure Reasons

The implementation of Lean, as any other business process change management, is believed to have enormous difficulties (Kettinger and Grover, 1995). For example, Larry, A.D. (1985) pointed out the top 10 most frequent implementation problems as the business tried to implement new strategic decisions – see Table 2.

	Ten most frequent implementation problems	%
1	Implementation took long than planned	76
2	Major unanticipated problems occurred during implementation	74
3	Co-ordination of implementation activities was not effective enough	66
4	Competing activities and crises distracted attention from implementation	64
5	Skills and abilities of implementation team were lacking	63
6	Training and instructions to lower level employees was not good enough	62
7	Uncontrollable factors in the external environment adversely affected implementation	60
8	Leadership and direction provided by department managers was not good enough	59
9	Key implementation tasks and activities were not defined in enough detail	56
10	Information systems used to monitor implementation were not adequate	56

Table 2: Most frequent implementation problems

Emiliani and Stec (2005), refers to a survey made by the Lean Enterprise Institute, in 2004, reporting the "State of Lean" based on data from 999 participants. According to it only 4% of participants described their progress as "advanced", while 46% described their Lean implementation efforts as "early". The report identified several "common obstacles" related to their experience in Lean implementation efforts – see Figure 6.
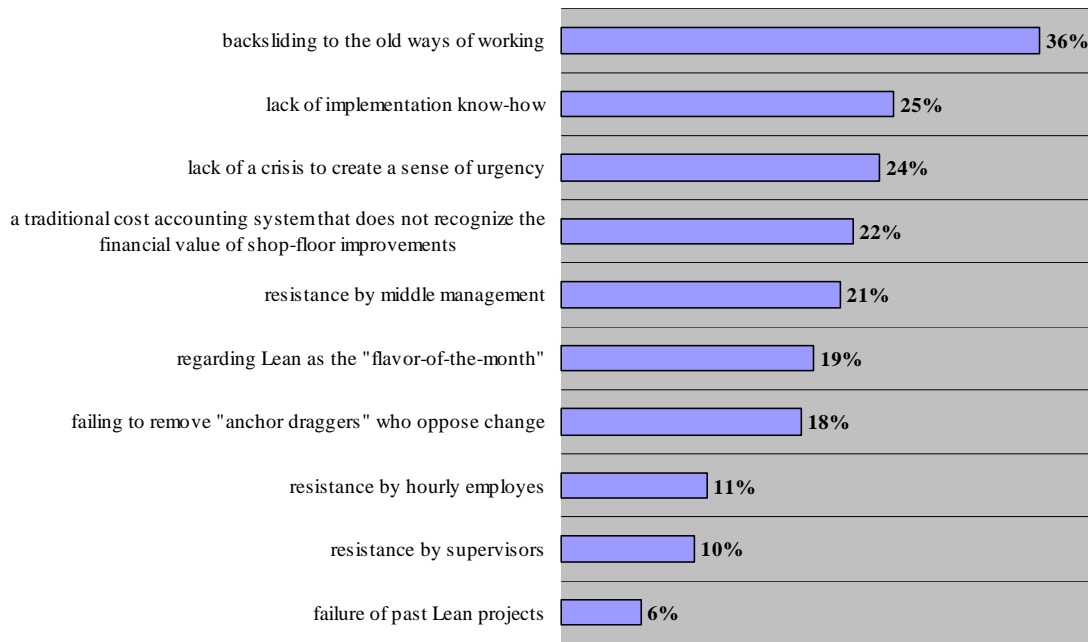
Figure 6: Common obstacles (Lean Enterprise Institute, 2004)

Numerous others authors have identified a variety of other potential reasons to the failure of a Lean implementation initiative. The most prominent of these are described below.

To aid analysis and structure, these reasons are summarised and classified to what the author considers to be a necessary holistic management approach of a strategic, managerial, structural, organisational and operational nature, required to promote effectiveness and efficiency to the implementation of such a transformation change.

- Strategic: refers to a long term plan of actions designed to empower and build common visions, generating an outcome differentiation.

- Managerial: relates to management activities: planning, organising, resourcing, leading or directing, and controlling; and management attitudes.

- Structural: relates to the elements and resources needed to increase the system capability in order to support changes.

- Organisational: relates to a specific collection of values and norms that must be shared by people and groups in an organisation and that must control the way they interact with each other, to support the organisational changes.

- Operational: refers to the process context and the actions needed to implement and sustain the performance improvement.

Table 3: Possible reasons for failure in the implementation of Lean

Reasons for Failure	Sources											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	Ranking
Strategic												
Lack of a clear vision and strategy	•			•	•	•	•	•		•		7
Lack of an effective communication strategy					•					•		2
Failure to create a sense of urgency					•							1
Failure to understand the scope of lean management system	•			•			•		•			4
Managerial												
Lack of a structured methodology & project management	•				•	•	•					4
Lack of management ability to operate in diverse environment						•						1
Poor cost and schedule estimation and planning						•						1
Poor consultation with all stakeholders						•						1
Lack of management commitment and involvement	•		•	•		•	•	•	•	•	•	9
Lack of strong leadership	•			•	•	•	•			•		6
Management turnover				•								1
Structural												
Lack of adequate financial funding						•						1
Lack of enough skills and expertise	•					•						2
Absence of a dedicated and fully resourced implementation team					•				•			2
Lack of a supportive human resources policy				•	•		•		•	•		5
Organisational												
Lack of a supportive organisational culture based on sustainable proactive improvement	•	•				•	•			•		5
Failure to engage employees & mobilise change champions	•				•		•		•	•		5
Lack of cross-functional participation				•								1
Ineffective communication particularly across functional boundaries						•	•	•	•	•		5
Operational												

Reason	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Lack of standardised mechanism of analysis and measure of value adding capabilities within organisations						•						1
Resistance to change from supervision and workforce		•		•			•			•		3
Failure to monitor and evaluate the outcome / Poor metrics				•	•		•		•			4
Complexity and high level of work involved	•											1
Not enough training							•					1
Not able to sustain initial efforts							•					1
Not expanding improvement from the initial efforts to other departments				•			•					2
Improvements in one area seemed to have negative impacts in others							•					1
Failure to expand lean implementation to the supply chain	•			•			•				•	4

(**1**) Backer, P. (2002); (**2**) Padgett, A. (2004); (**3**) Drew, J. et al. (2004); (**4**) Emiliany, M.L. and Stec, D.J. (2005); (**5**) Lucey, J. (2005); (**6**) Achanga, P. et al. (2006); (**7**) Bhasin, S. and Burcher, P. (2006); (**8**) Kilpatrick, J. and Osborne, R. (2006); (**9**) Tracey, M.W. and Flinchbaugh, J. (2006); (**10**) Worley, J.M. and Doolen, T.L. (2006); (**11**) Hines, P. et al. (2008)

According to this research it is clear that some reasons have more predominance and are therefore more relevant than others. This is justifiable by the number of times these reasons are discussed by the different mentioned writers and also addressed by others. They can be ranked within each group as it follows: (1) lack of clear vision and strategy; (2) failure to understand the scope of Lean management system; (3) lack of a structured methodology & project management; (4) lack of management commitment and involvement; (5) lack of a strong leadership; (6) lack of a supportive human resources policy; (7) lack of a supportive organisational culture based on sustainable proactive improvement; (8) failure to engage employees & mobilise change champions; (9) ineffective communication particularly across functional boundaries; (10) failure to monitor and evaluate the outcome / poor metrics and (11) failure to expand Lean implementation to the supply chain.

3.3 Analysis of the Findings

Strategic level

One of the biggest mistakes made by companies considering the use of Lean is to "jump into

the water" without a strategically focused plan. Many have failed a Lean transformation because management failed to establish a strategic plan for implementing it.

Unfortunately, most Lean efforts begin with a tactical approach, rather than a strategic one (Kilpatrick and Osborne, 2006). In most cases, Lean initiatives lack of a strategic integration perspective. They do not directly link to corporate strategy and goals, says Emiliani and Stec (2005). Kaizen initiatives are often applied haphazardly providing only "local benefits", usually in a completely isolation from the needs of the rest of the business. This is because Lean is seen by most organisations primarily as a "manufacturing thing", and not as a comprehensive management system wide gains.

Failure to understand the scope of Lean initiatives makes top management and executives not to see the link between clear improvements in the operational area and the opportunity to leverage those for the business as a whole (Baker, 2002). Companies are therefore starting their Lean efforts incorrectly, with the wrong focus. This problem may further be compounded by companies' reluctance to commit to Lean as a long term journey (Backer, P., 2002).

Managerial level

Despite the resurgence of interest in Lean over the past few years, there is still a shortage of expertise in implementing Lean. Case studies reveal that the major part of Lean implementations initiatives is late or over budgeted. Several authors maintain that these occurrences are a consequence of poor cost and schedule estimation and adequate project planning sequence, prior to implementation.

In fact "a lot of people try to get the jam first" but before this, there is a minimum of interconnected prerequisites that an organisation must take into consideration, such as: process capability, standard working procedures and etc. Baker (2002) instigated a three-year programme for getting the basics right. Therefore Lean does indeed require a bottom-up implementation and without a good project plan and a team of managers that thoroughly understands its roles and responsibilities in regards to the transformation, the initiative may be faced with delays, disbelief by the work-force or even failure (Nash and Poling, 2007).

Though many variables may affect the success of a Lean implementation, the lack of management involvement and commitment is probably the major cause that contributes undoubtedly to a Lean implementation failure (Achanga *et al.*, 2006). The importance of the

role of management support in any change program is widely acknowledged within literature.

Management that fails to embrace the implementation may intentionally or unintentionally "sabotage" the effort (Worley and Doolen, 2006). The lack of personal participation in improvement activities sends the message that Lean implementation is the job of lower-level workers and that top management does not have to get involved. Top management should not only demonstrate commitment and leadership, but it must also work to create interest in the implementation and communicate the change to everyone within the organisation. Management must be visibly connected to the project and participate in the Lean transformation events (Boyer and Sovilla, 2003).

Structural level

The research also demonstrates that success with Lean depends upon how HR plays a guiding and supportive role in an organisation's attempt to improve. Working organisation in Lean environment deals with more than job design (Forza, 1996). It emphasizes management style, skill and values and aims to incorporate job design into the organisation's employment strategy. The approach to job design is therefore characterised by cooperativeness, group problem solving and attitude control in what can be described as the social organisation of work.

In accordance with Tracey and Flinchbaugh (2006), within Lean, team working is important because the whole process must work together to build value for the customer. Nevertheless, this social organisation of work system implies a supportive HR policy that brings along a change of focus: from controlling to helping; from evaluating to empowering; from directing to coaching and from planning to listening (Bashin and Burcher, 2006).

Organisational level

Padget (2004) claims that one of the primary reasons most companies fail in their Lean implementation is because they fail to successfully change the culture.

Lean involves substantial change in the organisation and usually when important change occurs, the people in the organisation are afraid of the unknown and they do not understand the need for change. The creation of a supportive organisational culture is therefore an essential platform for the implementation of Lean (Achanga *et al.*, 2006). High-performing

companies are those with a culture of sustainable and proactive improvement, embracing empowerment and sponsoring the Lean principles through-out the value chain (Bhasin and Burcher, 2006).

Communication is also often cited in the practitioner literature as an important factor in Lean success. A dynamic relationship exists between a Lean implementation and organisational communications (Worley and Doolen, 2006).

However, organisations tend to under-communicate both prior too and during the implementation of Lean. Prior to the start of Lean implementation there is often a general failure to communicate the aims, intentions and plans as well as the expectations of the programme. This can generate concern, if not fear, and resistance at the imposition of Lean. During the Lean implementation, communication problems can arise through failing to keep people informed of progress, achievements and next steps, but also a breakdown in the one to one communication that needs to occur. This lack of support and individual communication makes that, negative perceptions and concerns are not correctly addressed and therefore demystified.

Organisations that are successful in Lean also improve their communications successfully, particularly across boundaries such as departments and functions (Tracey and Flinchbaugh, 2006). Communication in a Lean environment must be vertical, horizontal and two-way. Worley and Doolen (2006), claim that Lean requires a clear communication between value streams. Indeed Lean enterprises must have communication pathways that are efficient and broad.

Operational level

To succeed in a journey to Lean, the feedback must support the change. Therefore a company typically must overhaul the way it measures costs, speed, and quality (Swank, C.K., 2003). Indeed, managers often find that many of their company's favourite metrics actually inhibit efficiency and effectiveness.

Performance measures traditionally used are inappropriate, as these measures encourage short-term, small-scale or local optimisation only and variance reduction rather than improvement, and they also lack strategic focus and fail to provide information on customer needs (Bayraktar, E. *et al.*, 2007). It is necessary to develop dynamic measurement systems through realignment metrics with value stream perspectives, rather than statistic ones. It is the

best way to align an organisation's activities with its strategic objectives. Lean practitioner's preconized that performance and productivity should be always measured from the customer's perspective.

Failing to expand Lean to the supply chain is another difficult aspect and even a barrier to a successful Lean implementation (Kilpatrick, 2003). Bhasin and Burcher (2006), support that for a Lean program to succeed it is vital to get the suppliers on board. As well as extending across the enterprise, implementing Lean must also extends out into the supply chain.

Because of the need for just-in-time delivery of materials, minimization of inventories and Lean's dependence upon high quality products and services, companies need to bring suppliers into the improvement efforts. If critical suppliers cannot respect and accomplish these principles, then the benefits of Lean will be greatly diminished or even non-existent. The development of a Lean supply chain is probably one of the most difficult, but more financially rewarding, aspects of implementing Lean (Kilpatrick, 2003).

3.4 Identification of the Critical Success Factors (Theoretical Proposition)

The general lesson to be learned from the above practical difficulties for companies embracing a Lean transformation is that the change process needs to go through a series of phases that, in total, usually require a considerable length of time. Skipping steps creates only the illusion of speed and never produces a satisfying result. Moreover Lean encompasses a set of concepts and associated details that must be mastered in order to be correctly implemented. It is therefore worthwhile to examine the critical factors that, to a great extent, determine the success of the implementation. The nine factors of CRITICAL are:

- Clear understanding of strategic vision and goals

- Commitment by top management

- Excellent project management

- Organisational change management: cultural and structural

- Communication plan

- A great implementation team

- Training and education

- Performance evaluation

- Involvement of the supplier base

3.4.1 Clear Understanding of Strategic Vision and Goals

"A vision says something that clarifies the direction in which an organisation needs to move" (Kotter, 1995). One of the most fundamental elements in business improvement is having a clear compelling vision of how the company should operate, and the formulation of the right policies / strategies that can serve as the blueprint for any organisational success. It is also important to emphasize at this juncture that successful visions are those that can be translated into measurable goals and targets. The vision stage can then serve as "the precursor" for putting in place an enabling Lean strategy, based on mapping and determining the key requirements that can support the effective deployment and delivery of the key business imperatives.

Alignment of Lean strategy with the organisation's business strategy is also considered a fundamental principle (Bozdogan, K. *et al.*, 2000).

Well defined strategic targets help to keep the project team on track throughout the entire implementation process.

3.4.2 Commitment by Top Management

Successful Lean implementations have shown that leadership, commitment and participation by top management are the most critical factors in organisations embarking on Lean implementation, as they ensure a smooth management and system rollout. Not only is the requirement for setting the vision and developing a solid strategic plan, but it is also for boosting the energy, creativity and involvement of employees to a self-sustaining organisation (Womack and Jones, 2003).

Top management support and commitment does not end with initiation and facilitation, but must extend to full implementation of Lean system. Intervention from management is necessary for the adequate resources allocation of the project, to take fast and effective decisions, resolve conflicts, remove "anchor-draggers" and bring everybody to the same thinking, to promote company-wide acceptance of the project and to build cooperation among the diverse groups in the organisation. Top management needs to constantly monitor the progress of the project and provide direction to the implementation teams.

3.4.3 Excellent Project Management

One of the complexities associated with Lean implementation is related to the cross-functional integration nature of the system. Thus successful Lean implementation requires that the organisation engage in excellent project management. Lean project management differs from traditional project management not only in the goals it pursues, but also in the structure of its phases, the relationship between phases and the participants in each phase (Ballard and Howell, 2003). It must therefore include a clear definition of objectives, development of both a work plan and a resource plan, and careful tracking of project progress. And it should establish aggressive, but achievable, schedules that instil and maintain a sense of urgency.

The project scope must be clearly defined at the outset of the project and should identify the modules selected for implementation as well as the affected organisational processes.

A clear definition of project objectives and a clear plan will help the organisation avoid jeopardizing project process and complicate the implementation.

3.4.4 Organisational Change Management: Cultural and Structural

It is estimated that about half of enterprise system projects fail to achieve hoped-for benefits, because managers significantly underestimate the efforts required to manage effectively the wide range of changes involved. They do not understand that Lean principles will fundamentally change the way in which the organisation operates. This is one of the problematic issues facing current Lean implementation initiatives.

The existing organisational structure and processes found in most companies are not compatible with Lean principles and practices. Thus, implementing a Lean system management may force the reengineering of key business processes and / or developing new business processes to support the organisation's goals. And redesigned processes require corresponding realignment in organisational control to sustain the effectiveness of the reengineering efforts. This realignment typically impacts most functional areas and many social systems within the organisation. This requires a massive change in an organisation's structure, policies, and processes affecting the way employees use to do work and interact.

Clearly Lean implementation will trigger profound changes. If people are not properly prepared for the imminent changes, then denial, resistance and chaos will be predictable consequences of the changes created by the implementation. Thus, building the right

corporate culture environment for sustainable change and overcoming employee resistance are vitally important when embarking on an organisational change programme, such as a Lean transformation (Hines *et al.*, 2008).

It is important that an organisation goes through a carefully planned transformation that is based on adequate strategy and well defined methodology of implementation.

3.4.5 Communication Plan

A successful Lean transformation depends, in large part, upon how effectively management communicates with those affected by the transformation. This communication must address, at a minimum, what is happening, why it is happening and how it is happening (Mathaisel, 2005). More importantly, each individual and organisation affected by the transformation must understand how the transformation impacts him or her.

A communication plan is important in order to involve the personnel with Lean initiative by showing them how it works, how it is related to their jobs. Communication has to cover the scope, objectives and tasks of the Lean implementation project.

In a way to avoid the various communication possible failures, an open information policy has to be maintained for the project. It is therefore important to establish a communication program that can describe what should be communicated by whom and how often. It would help organisations to propagate their business strategy, customer requirements and work team (Coronado and Antony, 2002).

3.4.6 A Great Implementation Team

To implement Lean successfully, there should be a good implementation team that guides the company during the Lean journey. The team is responsible for creating the initial, detailed project plan or overall schedule for the entire project, assigning responsibilities for various activities and determining due dates. The team also makes sure that all necessary resources will be available as needed.

Lean implementation teams should be composed by individuals with a make-something-happen mind-set (Womack and Jones, 2003) who are chosen for their multiple skills (covering functional, technical and inter-personal areas), past accomplishments, reputation and flexibility. These people should be entrusted with critical decision making responsibility.

Management should constantly communicate with the team, but should also enable empowered, rapid decision making.

3.4.7 Training and Education

Various elements of the research show that training is a minor, but not insubstantial, issue. For some organisations they carried out so much training that they ran of steam without ever having moved to action, whilst for others they carried out little or no training and therefore failed to equip their team with the skills and knowledge required of how to address Lean tools and techniques. There are organisations who are concerned with undertaking very precise and extensive training that results in people receiving information overload without the practical experience to implement it or alternatively organisations who want to minimise to its maximum the training and get to action.

Obviously, the challenge is to select an appropriate plan for end-user training and education and to do this, organisations need to think about what skills and knowledge these individuals need.

It is however important to stress that a successful Lean transformation initiative will likely require the most extensive changes a company will ever have encountered. There will be a significant impact on every employee and every position. Therefore successful transition to Lean will require a deep understanding of its principles and practices, with extensive education and training at all levels. The focus must be on changing mental models, beliefs, behaviour and attitudes throughout the workforce (Bozdogan *et al.*, 2000).

3.4.8 Performance Evaluation

Measuring and evaluating performance is a very critical factor for ensuring the success of Lean implementation and sustainability. Performance measures that assess the impact of Lean management system must be carefully constructed.

Of course, the measures should indicate how the system is performing. Such measures might include on-time deliveries, gross profit margin, customer order-to-ship time, inventory turns, etc. But the measures must also be designed so as to encourage the desired behaviours by all functions and individuals. Performance in this context has got to reflect an integrated holistic concept. It has to embody the whole organisation and capture tangible and intangible aspects.

It is suggested that measurement takes place in a balanced perspective and for the purpose of providing useful information that can enable the decision making process and, which can help deliver the corporate objectives and therefore lead the business competitively forward.

Project evaluation measures must be included from the beginning. The project must be closely monitored until the implementation is completed. To complement this system, it is advisable that regular auditing and benchmarking are considered for optimisation of the potential available to business in all aspects. Furthermore, external benchmarking can bring new ideas, knowledge and best practices on dealing with internal deficiencies, streamlining process, optimising and redesigning for more extensive benefits. Such audits can take advantage of an array of existing tools than can be applied to scan both the organisational, managerial and technical sides of the business.

3.4.9   Involvement of the Supplier Base

Research from, Krizner (2001, Baker (2002) and Emiliani (2003), reports that supplier support is a critical factor for the successful implementation of Lean.

The adoption of Lean practices is associated with higher levels of integration of both information flows and physical flows with suppliers (Cagliano, 2006). Both dimensions are considered relevant for the Lean approach: the integration of information flows is a prerequisite to align and streamline processes; the integration of physical flows reduces waste and increases the efficiency of inter-company processes. In this way, companies need to extend the Lean model to the supply side, in order to benefit from supply chain integration alignment with the business strategy. In this light, supply chain integration is expected to be linked to the activities and improvement programmes carried out at the production level.

Consequently, Lean requires a close coordination with suppliers. Instead of the usual adversarial style, companies embracing Lean must place their purchasing emphasis on involving a transformation to partnership with suppliers. Supply chain coordination should be encouraged, i.e. working to common quality standards, deliveries and cost.

3.5 The Analysis of Personal Interviews

The main purpose of this section is to validate and complement the outcomes obtained from the systematic literature review described in the first part of this chapter.

In the follow-up, it has been determined for the interview script that, four topic headings, were of particular importance in order to place the remaining findings into context and help to identify others variables or factors relating to Lean implementation challenges. These topic headings (as also described in Appendix 2) include:

- **Contextual Factors and Organisational Strategy**: this section searches to identify both the internal and external factors and drivers that can influence an organisation's decision to engage in adopting the Lean paradigm. This section searches also to examine the role of the strategy as a key driver for linking Lean to effective and sustainable improvement;

- **Organisational Readiness for Improvement Transformation**: this section searches to identify the factors which affect the ability of an organisation to implement an effective Lean transformation;

- **Implementation Process and Outcomes of Lean**: this section searches to identify and outline key guidance features to the implementation process from relevant insights and recommendations given regarding the programme methodology, the appropriate objective-setting mechanisms and metrics evaluation. There maybe some overlap with Organisational Readiness section above.

- **Critical Failure Reasons in Implementing Lean**: in order to learn from past failures, this section searches to determine which implementation failure reasons occurred most frequently and are more critical as the organisations tried to implement Lean and the strategies to overcome them.

The objective is to compare and contrast the three groups of interviewees (Management Consultants, Academics and Lean Managers) and see if there are any common views.

The data analysis is focused on the top reasons they considered, for the failure of the implementation of Lean, including an indication of the degree to which they agree to be the critical success factors.

3.5.1 Comparison of Results

The interpretation of the analysis (see Table 4) is dealt with level by level and signals a number of key messages.

At a strategic level, the first and the last reasons (#1- Lack of a clear vision and strategy; #4-

Failure to understand the scope of Lean management system) are well supported by all groups and there is a great deal of agreement between the consultants and lean managers. This supports the literature findings - if a Lean transformation fails at this level, it is almost certain to be unsuccessful. There was broad agreement by all three groups that the Lean implementation model should be a defined process that must start with a strategy formulation to determine the role of Lean within the strategic vision of how the organisation needs to develop in the longer term. This vision must be then cascaded using a process of policy deployment that defines implementation steps and identifies areas requiring change.

At a managerial level, the results indicate that a greater emphasis is given to the lack of top management commitment and leadership. Top management lacks commitment to the system, does not see the profound changes it engenders, and / or does not actively participate in the implementation. Management commitment was therefore identified by everyone as a key element factor contributing to the success of a Lean implementation. Effective leadership was seen as an essential driver for sustained change.

At the structural and organisational levels, the results were more varied. The Lean Managers group emphasised the reasons #13 (Lack of enough skills and expertise) and #18 (Lack of cross-functional participation) as the most critical that can lead to implementation failures. On the other hand, the Management Consultants group identified the reasons #14 (Absence of a dedicated and fully resourced implementation team), #16 (Lack of a supportive organisational culture based on sustainable proactive improvement) and #19 (Ineffective communication particularly across functional boundaries) as the most likely to explain the unsuccessful results.

Notwithstanding this, there was a broad agreement indicating that the need to developing a real organisational culture of continuous improvement was a factor for successful application of Lean. This meant developing an awareness and understanding of processes, flow, waste, and customer value.

In all cases, effective clear communication to ensure participation and engagement at all levels of the organisation was seen to be crucial. Lack of communication was commonly agreed to be a potential implementation failure. A good communication plan during a Lean implementation has a number of benefits, including: (1) recognition of employee effort; (2) motivation enhancement; (3) sharing of knowledge across work streams or departments; (4) keeping the mission on track; (5) buy-in from other staff not involved in the process.

At the operational level, reasons #22 and #28 (Failure to monitor and evaluate the outcome /

Poor metrics and Failure to expand Lean implementation to the supply chain) got the biggest individual score from each group. Both groups identified and considered the outcomes' evaluation of Lean as a way of creating a culture of improvement, through baseline measurements and ongoing metrics. According to them, metrics must be calculated on a regular basis, must be shared on a regular basis and must be understandable by all employees in the organisation.

Getting the suppliers on board was also found to be critical, at this level. The survey responses corroborates that one of the pillars the Lean philosophy relies on, is synchronisation (pull flow) and for that is vital to expand the principles of Lean to the supplier chain. In fact, according to one's interviewee field experience opinion it is needed to expand it further to include the consumption process, so that the interests of the customer, the retailer, the distributor, the producer, and the suppliers can be aligned – "the challenge is to work with customers to optimise the process of consuming", she says.

Beyond all these items related to the implementation of Lean, one additional recommendation is suggested to help achieve successful long-term sustainability – celebrate the successes related to Lean implementation throughout the organisation as they occur, with the accompanying reward progress. Because Lean is an endless journey, if tension is sustained without recognising progress, organisation wide-problems leading to confusion and a lack of alignment, may follow. Simultaneously celebrating and raising awareness of the remaining performance gap is therefore a needed balancing act. The accompanying reward progress is seen as a more complicated challenge, as all solutions to the reward problem seemed to have downsides. However, it is agreed that no matter how a pay reward system aligns to Lean expectations, financial incentives cannot replace employee engagement and support.

Reasons for Failure	Management Consultant									Lean Manager								
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Strategic Level:																		
1. Lack of a clear vision and strategy									√								√	
2. Lack of an effective communication strategy							√									√		
3. Failure to create a sense of urgency						√									√			
4. Failure to understand the scope of lean management system							√											√
Managerial Level:																		
5. Lack of a structured methodology & project management						√									√			
6. Lack of management ability to operate in diverse environment				√									√					
7. Poor cost and schedule estimation and planning			√												√			
8. Poor consultation with all stakeholders			√											√				
9. Lack of management commitment and involvement							√											√
10. Lack of strong leadership								√								√		
11. Management turnover					√						√							
Structural Level:																		
12. Lack of adequate financial funding					√										√			
13. Lack of enough skills and expertise							√											√
14. Absence of a dedicated and fully resourced implementation team								√								√		
15. Lack of a supportive human resources policy						√											√	
Organisational Level:																		
16. Lack of a supportive organisational culture based on sustainable proactive improvement								√									√	
17. Failure to engage employees & mobilise change champions							√									√		
18. Lack of cross-functional participation						√												√
19. Ineffective communication particularly across functional boundaries								√							√			
Operational Level:																		
20. Lack of standardised mechanism of analysis and measure of value adding capabilities within organisations					√											√		

21. Resistance to change from supervision and workforce					√						√				
22. Failure to monitor and evaluate the outcome / Poor metrics						√									√
23. Complexity and high level of work involved				√				√							
24. Not enough training				√						√					
25. Not able to sustain initial efforts			√								√				
26. Not expanding improvement from the initial efforts to other departments			√					√							
27. Improvements in one area seemed to have negative impacts in others		√							√						
28. Failure to expand lean implementation to the supply chain					√								√		

Table 4: Reasons for failure: rank-scale evaluation from the Interviewees' perspective

(Note: the Academic interviewee was not prepared to commit to this rank-scale evaluation).

3.5.2 Summary of Results

The main lesson to be learned from the interviewees' experiences is that there is no single right way of implementing Lean. However, although some factors support a successful implementation (see critical success factors) others should be avoided (see failure reasons).

The commentary of one of the interviewees neatly summarises the key critical success factors in implementing Lean principles and practices effectively:

"Care should be taken to include the people of the organisation during Lean transformation for successful implementation. As continued success of the Lean initiative requires a cultural change within the organisation and this may need continuous organisation learning. Also Lean cannot be implemented as a stand alone and the aims of the Lean transformation have to be in line with the strategic goals of the organisation."

3.6 Synthesis

In this chapter it has been presented the common obstacles and it has been identified the common implementation errors that must be avoided in order to realise the full benefits of the Lean management system. It has been illustrated the ease by which Lean transformation

efforts can lead to less desirable outcomes when managers fail to fully grasp the implicit and explicit aspects of both task and behavioural elements of a new management system.

Several critical factors that determine the success of implementing the concept of Lean were identified: clear strategic vision, top management commitment, project management, organisational change, communication, performance evaluation, skills / expertise and supplier involvement amongst other factors; were classified as the most pertinent issues critical for the successful adoption of Lean in manufacturing environments.

For longer-term impact and sustainability, implementation of Lean should be tied to more strategic objectives. The implementation model must be a defined process that starts with strategy formulation to determine the role of Lean within the strategic vision of how the organisation needs to develop in the longer term.

4. TOWARDS A LEAN ENTERPRISE-WIDE TRANSFORMATION

In order to effect a successful Lean enterprise transformation, it is required an integrated set of steps and support activities that execute the strategic vision, program concepts, schedule, communication plan and the implementation strategy.

To this end, and on the basis of a comprehensive analysis of Lean literature combining research studies and organisational experiences in implementation models, followed by the interviews' relevant insights, the objective of this chapter is to develop a methodology through the construction of a novel roadmap for transitioning an existing manufacturing system to one that fully implements the Lean condition. Integration of engineering, human resources and business view points are incorporated into the roadmap that uses a multiphase approach structured on the life cycle of the transformation. It portrays the flow of phases necessary to implement, sustain and refine an enterprise industry based upon Lean principles and system engineering methods. Through the novelty of this approach it is the study's intent to answer in full to the second topic question addressed in this paper.

4.1 The Importance of the Adequate Implementation Approach

The implementation approach is critical for the success of Lean programmes. Different authors even argue that it may not be the concept itself, but the way it is implemented that is essential for success. According to Laugen and Boer (2007), a different implementation approach seems to make a difference in terms of: (1) short-term and long-term performance effects; (2) management commitment, involvement and especially persistence required; (3) pressure on employees involved in implementation and improvement activities.

Indeed, different Lean implementation approaches influence potential performance benefits which increase the nearer Lean practices reach full implementation.

Therefore implementation needs to be understood as an organisational change, which involves change at individual, group, and organisational levels, that occurs through a set of steps or activities that need to be defined at the organisational level and conducted at its operational level.

Much of the literature on implementation of Lean present generic guidelines and prescriptive models, generally approaching change as a one-off activity, not consider that it should be managed as a continuous event within organisations. Empirical results have suggested that the use of such frameworks has led to outcomes that were not as successful as expected.

The need for a better conceptualisation of implementation as a practically oriented path is clear. The development of a more holistic and integrated approach perspective on processes implementation will offer appropriate guidance for companies aiming to successfully implement Lean.

4.2 Development of the Roadmap

The roadmap structure presented in Figure 7 is rooted in the concept of a business process change approach as baseline requirements intended to provide a systematic guidance to the implementation process. It is comprised of three major phases, each phase creating the conditions necessary to successfully progress through the life cycle of the transformation:

(1) The first component is the transformation strategic planning phase, which specifies the actions associated with the decision to adopt the Lean paradigm. Best practices continue to demonstrate the benefits of a strategic plan to focus the effort and energy of an organisation toward the achievement of common goals, objectives, and performance metrics. The success of the organisation is highly dependent upon a focused vision set forth in a carefully conceived plan.

(2) The second component is the transformation integration phase, in which the environment and conditions necessary for a successful change in the enterprise are created;

(3) The third component is the transformation implementation phase, where the transformation of the enterprise is launched into detailed planning, executed and monitored. Transformation implementation must be built on a strong centralised vision, continuous improvement, and progress measurement.

Starting from the identification of a clear need, the roadmap is structured using an enterprise life cycle perspective, combining engineering approaches and Lean principles to portray the overall flow of phases and action steps necessary to implement, sustain, and continuously refine the entire manufacturing enterprise system.

As shown in Figure 7, there are four fundamental stages that should be followed, namely the Preparation, Design, Implementation and Use & Improvement Stages. The stages are sequential; they follow the fundamental principles of systems engineering; and they are based on the life cycle of the enterprise. Specified within each stage is the collection of activities and action steps in a recommend order of precedence that one can use to design, develop, test,

evaluate, integrate and implement the Lean manufacturing transformation.

However, each organisation is unique with its own culture, legacy policies and systems, and a common path for all, will not always work. Internal progress review or feedback should be taken often and the path to Lean may need some alteration or enhancement once underway to get the performance results desired.
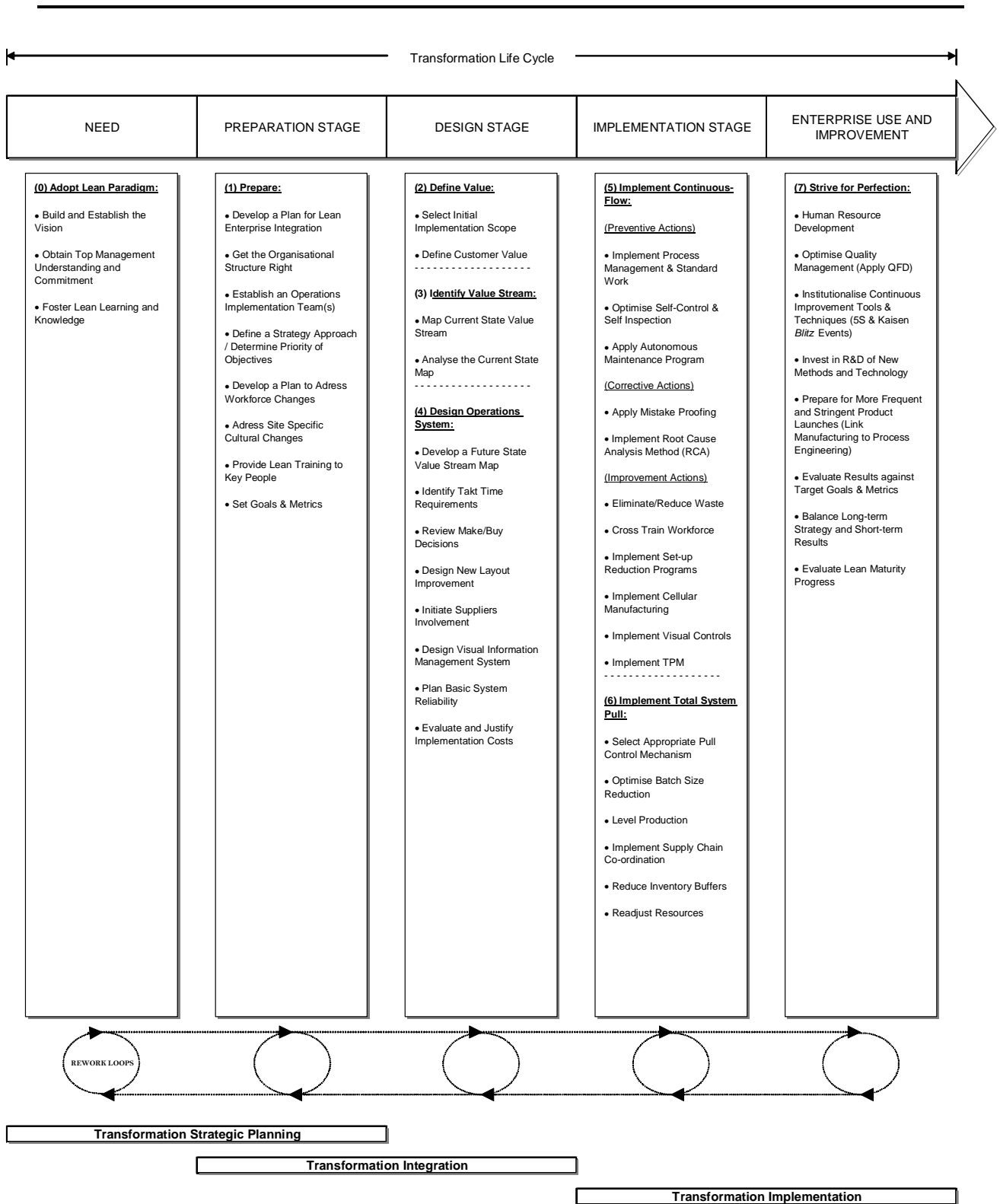
Figure 7: Lean Enterprise Transformation Roadmap

4.2.1 Recognising the "Need" for Change

There are basically five important reasons to adopt the Lean paradigm: (1) to survive among Lean competitors; (2) focus on resource sharing to gain a strategic advantage; (3) to meet customer expectations; (4) to respond quickly to opportunities and threats in environment and (5) to eliminate waste and increasing value. But, regardless of the reasons for choosing Lean, the more important for a company is to identify the strategic imperative, the forcing function for transitioning to Lean. The business need for Lean must be clearly determinate.

A company must then be aware that implementing the Lean paradigm requires revisiting every assumption, practice, and process associated with customer interactions, product design, production, quality assurance, human resources, work supervision, organisational structure, business systems and supplier relations. The organisation must learn to do business, behave and see value in fundamentally different ways. Therefore a company should consider three preliminary crucial steps before starting the Lean journey.

Step 1: Build and Establish the Vision

The first step and one of the major challenges is building a Lean vision by envisioning what should be accomplished differently in the collective behaviour of the enterprise. How the company, its leadership and its employees, can be transformed internally, usually from a mass-production mindset to one based upon Lean principles and practices.

While developing a Lean vision, it is critical to discuss, develop and fully understand the main philosophies that should drive a company. The Lean vision must become a major integral part of the company's strategic business plan, thereby modifying the company's mental model. This is the only possible way to align the Lean effort to maximise results, both culturally and financially.

There are no shortcuts to the development of the vision and the implementation of a total Lean system. Having a long term vision is essential. The vision must look at least three to five years into the future and Lean should be seen as a direction, rather than as a state to be reached after a certain time (Karlsson and Ahlstrom, 1996).

The Lean vision must be extended and applied to every aspect of the enterprise. Ultimately it must be communicated and explained to the entire team and to all key stakeholders with whom the enterprise interacts.

Step 2: Obtain Management Understanding and Commitment

The second step in developing and implementing a solid Lean transition is to get the understanding and commitment of the organisation executive management team.

All senior managers need to become fully knowledgeable about the Lean paradigm. They must understand that they are being asked to buy into a paradigm shift that fundamentally changes the way the enterprise acts and behaves. The inability to understand the full impact may lead managers to adopt strategies that may seem rational on the short-term and from a local perspective, but undermine the system as a whole on the long run.

The decision to pursue Lean, once made, must be viewed as non-negotiable and irrevocable. Full commitment of all senior managers is mandatory. The success of the Lean transition relies heavily and critically on their full involvement. All of the direct reports must be equally committed to the need for, demands of, and benefits of Lean.

Step 3: Foster Lean Learning and Knowledge

Before launching an organisation-wide Lean initiative, the company should conduct introductory Lean knowledge for all levels of supervisors and management. Essentially all key leaders need to be brought up to speed on the Lean paradigm.

An overall framework must be developed to foster Lean learning. Visits to other organisations that have successfully transitioned to Lean are particularly helpful. Outside consultants can be used.

Through the decision to change the organisation's operating philosophy to Lean, the company needs to develop the importance of organisational learning into which senior managers must increase employees' capabilities in order to better understand and effectively manage the organisational change and its environment.

4.2.2   Preparation Stage

The preparation stage is where the strategy is defined and the support infrastructure is put into place for the transformation to Lean. During this phase a cross functional group is established and given the authority, responsibility and accountability for the transformation. Interfaces with other parts of the enterprise and key business systems are recognised and defined. Major issues such as workforce changes and culture attributes are addressed. Policies and guidelines

are set into place as well as the metrics to measure implementation progress.

Step 1: Develop a Plan for Lean Enterprise Integration

Transitioning to a Lean operating philosophy can not be done to its potential without integration with all business functions. A major shift towards Lean practices implemented in the shop areas alone will directly impact the operations in procurement, material management, product definition, facilities, human resources and financial management. These areas not only need to be aware of what is being done but also must become part of the process so that their internal operations can be modified to facilitate the change.

Step 2: Get the Organisational Structure Right

Companies that have successfully transitioned to the Lean paradigm have found an effective structure in Integrated Product / Process Teams organised as self managed work teams. Organisational alignment by core process is also widely evident in Lean enterprises. These organisational changes enhance focus on customer value, eliminate silos and promote more effective product / service delivery.

Furthermore and rather than reporting up to a chain of command through a multi-layer pyramidal structure, work teams should be focused horizontally on a linked set of activities along the value stream. Such a structure facilitates ongoing efforts to minimise waste via continuous improvement initiatives, thus increasing efficiency and flexibility, enhancing the workers' value to the enterprise.

Last but not the least the organisation must modify extensively its various systems, structures and policies to bring them into compliance with a Lean transformation vision.

Step 3: Establish an Operations Lean Implementation Team(s)

To implement Lean successfully, there should be a good and fully dedicated implementation team that coordinates the all phases and guide the company during the Lean journey. The implementation team should consist of various people having high qualifications and knowledge about the enterprise. The mandate of this group is to: (1) develop a high level strategy and plan for its execution; (2) provide resources when needed; (3) identify and break barriers to implementation as they are encountered; (4) monitor and ensure that overall

implementation is not adversely impacting current performance; (5) frequently report on progress directly to senior top manager of the organisation; (6) provide learning in Lean practices and tools and (8) facilitate Lean implementation projects.

Step 4: Define a Strategy Approach / Determine Priority of Objectives

There is a need to establish a strategic plan approach that addresses the organisational and implementation issues in light of the resistance and pitfalls that are typically encountered in changing the way people think and behave while achieving the goals of Lean operating philosophy.

Also important is to determine where to concentrate your efforts to maximise the total benefit while achieving the overall objectives of the enterprise's long-range strategic plan. The premise is that a strategically focused Lean implementation will be able to produce a quicker and a much more lasting benefit to the company.

Step 5: Develop a Plan to Address Workforce Changes

People more than anything else are what make an organisation either excel or fail in performance. During the course of becoming Lean, people will be transitioning in their work roles and this will affect the way people use to do work and interact. There will be scepticism as to the real motives for this initiative and not surprisingly, the pace of improvement can be greatly slowed. Therefore, it is critical to establish a clear, fair and supportive human resources policy at the beginning in order to address workforce changes during the process of becoming Lean, including changes in job content, transfers & reassignments and the possibility of reduced staffing levels. It is important to consider and articulate the workforce's feedback for implementing the needed changes.

Step 6: Address Site Specific Cultural Changes

A Lean implementation program must not be a "copy cat" program strictly following another company's success story. Rather, the Lean implementation program must suit the nature and needs of the organisation.

Every organisation has its own and unique culture which is the sum of many individuals' habits related to the work in the organisation. Modifying the company culture can be a

delicate and risky step because it mandates a profound modification of human behaviour to alter long-established relationships. Therefore it is required the use of good change management techniques to get the buy-in required to develop and change a company's culture. It is fundamental to simultaneously, stress responsibility, self reliance and trust in one's own abilities and foster knowledge sharing and learning. Investigation indicates that successful companies did this at a very early stage in order to sustain a successful Lean journey.

Step 7: Provide Lean Training to Key People

Lean does require a considerable investment in education and training. Many companies, however, start with large-scale Lean training before selecting any specific approach. Unless the training is carefully coordinated, there is a risk of the learned skills not being applied correctly. An extensive program of education and training is required at all levels.

Training should first start with the senior leadership with the objective of obtaining a correct understanding of Lean principles and what their role will be as the organisation moves toward becoming leaner. The next training group must include those individuals that will be leading directly with Lean projects. Their training must be more intense and consisting of both theory and hands on application under an experienced teacher and practitioner of Lean practices. Training of the workforce for small group problem solving, communication and statistical process is also necessary in order to develop the appropriate skills. At last, the third training group encompasses the rest of the staff organisation, which should receive a short course on Lean philosophy as well as the organisation's plan for implementation.

Step 8: Set Goals & Metrics

A clear specification of the target objectives and metrics is necessary to show the progress of the company Lean efforts. A time-phased improvement targets must be mapped out. Targets must stretch the organisation but they should be attainable. For measurement to be cost effective, it must be designed and targeted to support the business goals of the organisation. Goals and metrics for the Lean transformation must be aligned with the business strategy. This can take the form of a balanced set of metrics such as product throughput time reduction, total product cost, customer satisfaction scores and overall product quality, are some examples.

The goal-driven measurement process produces measures that provide insights into important management issues as identified by the business goals. Since these measures are traceable back to the business goals, the Lean activities and practices are better able to stay focused on their intended objectives.

4.2.3 Design Stage

This stage focuses on the analysis of the current state condition and the definition of each one of the activities and steps to cover future state enterprise performance, organisational and value chain structures, technology, human resources, facilities, and operational requirements.

4.2.3.1 Define Value

The starting point for Lean is "value" as defined by the end customer. Defining value requires thinking from the customer's perspective and working inward to the company's capabilities and core processes.

Step 1: Select Initial Implementation Scope

Top management must determine what value streams "to attack" and in what order. Choose a value stream that is important to the company, such as a key product line to a key customer or segment. Focus on a specific value stream avoids confusion over the different routes or processes adopted for different products or different customers. This rollout approach, coupled with strategic alignment to goals and objectives, provides overall guidance to various departments, divisions or value streams as their sub-plans are created.

Step 2: Define Customer Value

Lean improvement efforts should be prioritised based on the potential to eliminate waste from the end-use customer's perspective. Specifying what does and does not create value from the customer's perspective and not from the perspective of individual firms, functions and departments, clearly is a prerequisite to Lean. In fact, waste enters into the production system when requirements of internal or intermediate customers are mistakenly taken for that of the ultimate user of the product.

"Value" definition can be broken down in different ways, but almost always includes as minimum elements: product quality, delivery schedule, performance and cost target.

4.2.3.2 Identify Value Stream

Once customer value is defined, the enterprise must determine specifically how that value can be created and delivered in the most efficient and cost-effective manner. The value stream analysis serves to see how the company is really operating. It identifies when and where value is being added, and where waste is occurring along the entire path of the product or service.

Value stream mapping (VSM) provides a means to easily recognise and communicate what is taking place thus allowing team members to more readily target waste elimination. The value map should define overall flows or exchanges between the various entities or domain owners that comprise the value stream. This involves the movement of materials and information across the value stream – from the resource inputs that go into making products and services to the final consumption of the product or service.

Step 1: Map Current State Value Stream

Before starting detailed analysis of any core system it is useful to develop an overview of the key features of that entire system. The use of value stream mapping to establish the current state is essential. Until a current-state map is drawn, people – including senior managers – are unaware of the large amount of waste that exists in a system process as well as the existence of confusing information signals.

From the value stream map one can articulate the data in may forms. Through analysis of current material and information flows it is possible to: (1) identify major sources of non-value-added time in a value stream; (2) envision a less-wasteful future state; and (3) identify the technological changes necessary to transform the operations system into a Lean one.

Step 2: Analyse the Current State Map

After the preliminary technical design is complete, it should be analysed. The analysis of the map must consist of identifying the various ways in which the Lean principles can be applied. These are likely to include: moving from a push to a pull process; reducing batching; balancing the capacity of the different stages of the process; eliminating non value-adding

steps; moving decision points to earlier in the process; simplifying individual steps; reducing the cycle times or changeover times of individual steps; improving the flow of information between steps, as well as other specific improvement activities.

4.2.3.3 Design Operations System

The concept behind this phase is to do the high level design of the operations system. This design must recognise that the implementation process will take several phases. Therefore the key point is to consider the system design in total more than focus in the details of the implementation. It is important to understand where and how the operations system will evolve and determine how the manufacturing processes will operate on a day-to-day basis.

Step 1: Develop a Future State Value Stream Map

When all the possible improvements have been identified and considered, the next step is to develop a single, future state map to determine how the system will operate in the future.

The new design should be tested against the existing system. This is done to ensure the anticipated changes can be implemented. Too often, organisational factors impede the implementation of Lean practices. It is far better to try to predict which organisational factors will obstruct the implementation of Lean operations and adjust for them in the design phase than to wait for the implementation phase.

The future state map serves as a blueprint for planning and constructing the system.

Step 2: Identify "Takt Time" Requirements

In the Lean operating environment, optimising production around "takt time" (the rate at which each product needs to be completed to meet customer requirements) becomes a central focus. A production system must be designed to address a range of takt times that will meet a variable customer demand. The idea is to create a system that will work well with many different customer demand rates, regulating inventories and activities to achieve a consistent flow to the customer. The minimum "takt time" will establish the maximum capacity of the system and the maximum "takt time" will establish the minimum capacity of the system.

Step 3: Review Make / Buy Decisions

After designing the future value stream and determining the operation system "takt time", it is often necessary to review previous make / buy decisions. Often certain types of parts or assemblies naturally fit a new value stream or a new layout. Therefore, it makes sense to group all "similar" parts or assemblies that can be processed within the production system "takt time". This requires the review of previous make / buy decisions to pull in those parts and or assemblies that fit the internal value stream and to outsource those parts that do not conform to internal processes or value activities planned.

Step 4: Design New Layout Improvement

The intent of a good plant layout is to increase the velocity of products and make the production cycle predictable. The reconfiguration of the existing layout into either a cellular layout or a flexible manufacturing system generally entails significant movement of equipment, where production activities are rearranged so as to link process steps in the order needed to create a continuous, one-piece flow to make the product. The new layout must correspond to the sequence of operations and must minimise handling of material and work-in-process inventory storage.

The key in such a new layout design is to ensure that each of the operations can be completed within the takt time.

Step 5: Initiate Suppliers Involvement

Determination of production lead time is usually the combined result of processes operated by suppliers and those applied in-house. Suppliers must be therefore a major consideration in the future value stream.

With the production system takt time and the layout defined, the suppliers need to be synchronised with the production system. The ultimate goal is for suppliers to deliver orders directly to the point of use only slightly before the item is actually needed. The company needs to involve its suppliers in the improvement efforts, minimising inventory by applying Just-In-Time (JIT) techniques. The organisation needs to actively develop links with suppliers and working closely with them for mutual benefit, and the key to that is visibility.

The operations system design should consider the systems that will provide the necessary

information to the suppliers to make it possible for them to conform to this new system design. "Suppliers must be able to "see" into their customers' operations, and customers must be able to "see" into their suppliers' operations (Bill Di Benedetto, 2007).

Step 6: Design Visual Information Management System

To enable a Lean operations system, the information system should be timely and understandable to help everyone manage and improve the process. If information is visible at the workplace, problems are detected earlier and improvements can be made, or monitored more easily. The visual management activity emphasises frequent revision of the performance figures, which encourages and motivates managers and shop floor workers to improve these figures continuously. It is therefore important that the design of the visual management system takes the concept of shared knowledge and responsibility into consideration, to support flow and pull.

Step 7: Plan Basic System Reliability

Once the processes have been mapped, it is time to look at the reliability of the plant and equipment. In a Lean manufacturing environment, equipment reliability is a critical component of producing high-quality products in the right amount at the right time at the lowest possible cost. With production equipment linked in a continuous flow arrangement, it is important to have those production resources available when they are needed, because in this new production system design there is no (or little) safety buffer to alleviate system perturbations. The way to ensure that unplanned perturbations are avoided is to improve the reliability of the production system through total productive maintenance technologies.

Total Productive Maintenance (TPM) seeks to engage all levels and functions in an organisation to maximise the overall reliability and effectiveness of production equipment. TPM addresses the entire production system lifecycle and builds a solid, plant-floor based system to prevent breakdowns, defects and accidents.

The system design phase is therefore the best time to plan for a reliable system in order to maximise effectiveness and efficiency and optimise cost-effectiveness.

Step 8: Evaluate and Justify Implementation Costs

This new future state value stream and its system design will most likely involve investment. A cost-benefit analysis model must be developed in order to analyse the impact of different conditions. Costs must be checked to ensure that the process improvements propositions shown through their operational metrics can be translated into the expected cost savings. Although operational data can be reported more easily in real time than cost data, the capability to evaluate and report cost information is important to prioritise and cost justify improvement efforts, as well as tracking the benefits of these improvement efforts.

4.2.4 Implementation Stage

Implementation is the stage where the changes on the shop-floor and supply chain take place. This stage deals with the selection of the most adequate techniques to provide in an integrated and effective way, the elements being able to execute the processes as they were defined in the design stage. During this stage, facility and operations system are constructed and modified in accordance with Lean practices. Implementation must consider both internal and external interfaces. The implementation process is approached considering the great care that must be given to prevent disruption to current operations while simultaneously implementing enterprise changes. The following sections discuss the main steps in this stage.

4.2.4.1 Implement Continuous-Flow

Lean is built around the concept of continuous-flow processing. This phase marks the conversion from a traditional batch and queue production system into a continuous flow system. Continuous flow can only be achieved when disruptions in the system are eliminated. Common disruptions include late deliveries, equipment failures, operator delays, defective work, machine setups and operator error. The following steps should be regarded as mechanisms to overcome these disruptions.

Step 1: Implement Process Management & Standard Work

A process is a series of activities that takes inputs and produces one or more outputs. It is definable, relatively predictable and repeatable. Process management is a disciplined approach applying preventive methodologies to improve process performance by increasing

effectiveness, efficiency and adaptability. Process management ensures: that quality products arrive on time, first time and every time; better understanding of the whole process and of the impact of work on customer delight; clarified roles and responsibilities; easier integration for new employees; and reduced frustration.

Standard work is defined as simplified and structured work to ensure consistency and repeatability over time. It is achieved by a disciplined creation of requirements, work methods, tools, process, procedures and work instructions. Standard work ensures that the best practices are imbedded into routine job performance.

Step 2: Optimise Self-Control & Self-Inspection

In addition to provide the optimal conditions for process operation and control, establishing self-control has a significant, positive impact on the working environment and the individuals in it. Whenever possible, the design of the quality control system should stress self-control by the operating forces. Once self-control is established, self-inspection should be developed. Self-inspection permits the worker to check that the product adheres to quality standards before it is passed to the next station in the production cycle. Production and front-line workers are made to feel more responsible for the quality of their work. Feed-back on performance is immediate, thereby facilitating process adjustments.

Step 3: Apply Autonomous Maintenance Program

Autonomous maintenance, a key aspect of TPM, trains and focuses workers to take care of the equipment and machines with which they work. Through autonomous maintenance, operators learn to carry out important daily tasks that maintenance people rarely have time to perform. These "*housekeeping*" tasks including cleaning and inspecting, lubrication, precision checks, and other light maintenance tasks, allow operators to maintain equipment and to identify and resolve many basic equipment problems, preventing breakdowns or equipment malfunctions.

To achieve the goals of autonomous maintenance, it is clear that the program must involve teams of production and maintenance people, daily activities to maintain the condition of the equipment, cross-training to improve operator skills, and participation of operating personnel in the maintenance delivery process.

Step 4: Apply Mistake Proofing

Product defects are wasteful and if not discovered early in the manufacturing process they can lead to unneeded cost and customer dissatisfaction. Mistake proofing is a mechanism that prevents defects by eliminating the possibility of error at is source. There are two types of Mistake Proofing: Control and Warning. Control is achieved by stopping the process before mistakes happen; Warnings are achieved by indicating a situation that requires an intervention during the process.

Step 5: Implement Root Cause Analysis Method (RCA)

This is a method for determining the root cause of a problem, applying the best possible solutions and ensuring that the problem does not recur again by following through and standardising the solutions. It consists of eight steps of equal importance: (1) describe and understand the situation; (2) identify required resources to detect the root causes; (3) identify, select and prioritise probable root causes; (4) validate probable root causes; (5) identify, select and prioritise potential solutions; (6) validate potential solutions; (7) implement action plan and monitor effectiveness of solution; and (8) standardise similar process.

Step 6: Eliminate / Reduce Important Waste

Anything that, interrupts the flow of products or services through the value stream and out to the customer, is designated waste. All the principles of Lean are designed to eliminate or reduce this waste. Waste encompasses all activities that wastefully consume resources but do not add value. The focus here is to achieve a Lean process flow by eliminating: (1) unnecessary parts (inventory, finished goods, WIP, etc); (2) unnecessary resources (labours, tools, machines, etc); and (3) unnecessary processes elements.

Step 7: Cross Train Workforce

Smooth and continuous flow of work often depends on how well the workforce is cross-trained to support the total process flow. Employees can perform a variety of functions and thereby provide greater flexibility. Furthermore, cross-trained employees are able to step in for absent employees without disrupting flow, quality, and quantity of work. Cross-training offers a wide variety of other benefits. For example, a well-designed program can help reduce

costs, improve employee morale, reduce turnover and increase productivity.

To be effective, a cross-training program must be carefully planned and organised. There are a number of decisions that a company must make before the program can get started. For example, it is important to decide who will be eligible for training, whether the training will be mandatory or voluntary, whether the training will be restricted within job classifications or open to other classifications, and whether it will be administrated internally or externally. Prior to implementation, it might be helpful to set up a task force of consisting of both management and employees to research the pros and cons of cross-training for the company, assess the feasibility of setting up a program, work out the implementation issues, and set up a realistic schedule for each position.

Step 8: Implement Set-up Reduction Programs

Set up reduction is a key factor in the successful implementation of Lean production. Set up reduction is a process improvement activity targeted at reducing the amount of time and effort required to change over production from one product to another. Reducing set up times gives equipment and processes the flexibility to respond to customer needs from shortened lead times. Set up reduction facilitates smaller batch sizes which reduce floor inventory and space requirements and give quicker recognition of product defects. In fact without the reduced batch sizes that reducing set up times enables, none of the other components of Lean (like JIT, total Quality Management, Pull Systems, Waste elimination, etc) can be effectively implemented.

There are basically six techniques that can lead to set up reduction: (1) Separate internal from external setup operations; (2) Convert as much of internal to external setup operations; (3) Standardise all setups; (4) Adopt parallel operations; (5) Eliminate Adjustments; and (6) Mechanisation.

Step 9: Implement Cellular Manufacturing

It is vital to group closely all the process activities required to make a product (or related group of products), in order to reduce transport, waiting and process time. In cellular manufacturing, production work stations and equipment are arranged in a product-aligned sequence that supports a smooth flow of materials and components through the production process with minimal transport or delay. Implementation of this Lean method often represents

the first major shift in production activity and shop floor configuration, and it is the key enabler of increased production velocity and flexibility, as well as the reduction of capital requirements, in the form of excess inventories, facilities, and large production equipment.

Rather than processing multiple parts before sending them on to the next work station or process step, as is the case in batch-and-queue system, cellular manufacturing aims to move products through the manufacturing process one-piece at a time, at a rate determined by customers' needs. Cellular manufacturing can also provide companies with the flexibility to make quick changeovers to vary product type on the production line in response to specific customer demands. The approach seeks to minimise the time it takes for a single product to flow through the entire production process.

Cellular manufacturing methods include specific analytical techniques for assessing current operations and design a new cell-based manufacturing layout that will shorten cycle-times and changeover times. To make the cellular design work, an organisation must often replace large, high volume production machines with small, flexible, "right-sized" machines to fit well in the cell. This transformation often shifts worker responsibilities from watching a single machine, to managing multiple machines in a production cell. The implementation of cell manufacturing involves the redefinition and reassignment of jobs.

The biggest challenge when implementing cellular manufacturing in a company is dividing the entire manufacturing system into cells. There are some costs of implementing cellular manufacturing; however these costs have to be justified by the cost savings that can be realistically expected from the more flexible manufacturing system being introduced.

It is important to note, however that cellular manufacturing is not appropriate for all companies and many companies successfully implement Lean without implementing cellular manufacturing methods. For example, some industries require large batch processing due to the nature of the equipment or significant waiting times between production stages and therefore these would not be suitable for cellular manufacturing.

Step 10: Implement Visual Controls

The intent of visual control is increasing efficiency and effectiveness simply by deliberately making things visible. When things are visible, they are kept in conscious mind. It also serves to ensure that everyone has a common viewpoint of what is being displayed.

Visual control is an essential element of Lean implementation in that it provides the ability to

manage variances in process conditions (machines, materials, methods and manpower), and in product outcomes (quality, delivery and cost) at the source where the product is being made, while the product is being made. Visual controls reduce the opportunities to make errors and help highlight, at an early stage, potential delays and disruptions. Furthermore, visual controls enable someone to walk into the workplace and know within a short period of time what's happening with regards to production schedule, workflow, inventory levels, resource utilisation, and quality. These controls should be efficient, self-regulating and worker managed.

At the "heart" of implementing a visual control system is the concept of the 5S principles.

Step 11: Implement Total Productive Maintenance (TPM)

Continuous flow manufacturing will not allow for frequent, unplanned equipment down-time. Total Productive Maintenance (TPM) is an excellent method for meeting the demands continuous flow manufacturing places on equipment.

TPM is designed to maximise equipment effectiveness improving overall efficiency by establishing a comprehensive productive-maintenance system covering the entire life of the equipment, with the participation of all employees from top management down to shop-floor workers, to promote productive maintenance through motivation management or voluntary small-group activities (Kathleen E. McKone *et al.,* 1999). TPM provides a comprehensive company-wide approach to maintenance management which is usually divided into short-term and long-term elements. In the short-term, attention is focused on an autonomous maintenance program. In the long term, efforts focus on new equipment design and elimination of sources of lost equipment time.

The major TPM objectives are Maximise effectiveness and efficiency (Lead Time), Improve reliability and maintainability (Quality + Lead Time), Optimise cost during life cycle (Cost-effectiveness), Improve employee skills (Operators & Maintenance), Create a proper environment for teamwork.

4.2.4.2 Implement Total System Pull

Having established a platform of stability and the necessary level of flexibility, the team is now ready to bring everything together in a pull system, in which the flow on the factory is

driven by demand from downstream pulling production upstream. This means that no materials will be processed until there is a need (signal) from downstream. The specific implications of this are as follows: (1) Orders start at most downstream stage; (2) Product is pulled through production based on demand from downstream process; (3) Rate of production is driven by downstream consumption rates.

The ideal of pull system is that the materials will be available from the supplier (upstream stage) when the customer (downstream stage) needs them. This means that all inventory in the factory is being processed, as opposed to waiting to be processed.

In this phase the intent is to link the various flow operations that have been established throughout the production system and to establish pull operations across all the processes / operations / cells within the entire production system.

Step 1: Select Appropriate Pull Control Mechanism

A basic requirement of pull systems is the existence of real time control signals that provide the workstations with information about when to work or stay idle. This information varies over time to reflect the current state of WIP in the system and the current level of external demand.

There are several control mechanisms: Kanban, Constant Work in Process (CONWIP), Base Stock or hybrids of several of these different mechanisms. It is important to identify the conditions under which one of these control systems becomes superior to the others.

By far the most popular pull control system is the Kanban Control System. Kanban systems are among the simplest, effective and inexpensive means for manufacturing production and inventory control, which can be introduced and adopted in various manufacturing environments. Kanban is a pull-based material replenishment system that uses visual signals, such as colour-coded cards, to signal to upstream workstations when inputs are required at a downstream workstation.

Step 2: Optimise Batch Size Reduction

Because Lean calls for the production of parts to customer demand (pull system), product components, subassemblies and final products must flow through the production system in the smallest adjusted batch sizes possible (necessary to match up with customer demand) with the

ideal being one piece flow, so that work-in-progress between processing stages can be minimised. Not only does this reduce inventory-carrying costs, but also production lead time or cycle time is approximately directly proportional to the amount of WIP. Therefore, smaller batch sizes shorten the overall production cycle, enabling companies to deliver more quickly. Shorter production cycles increases inventory turns and allows the company to operate profitability at lower margins, which enables price reductions, which increases sales and market share.

Step 3: Level Production

Key to implementing a pull system is the levelling of the production to match the mix of products demanded by the customer over a specific interval of time. Production levelling, also called production smoothing, aims to distribute production volumes and product mix uniformly over time in order to minimise variations, peaks and valleys, in the workload. Any changes to volumes should me smoothed so that they occur gradually and therefore in the most non-disruptive way possible. This will also allow the company to operate at higher average capacity utilisation while also minimising changeovers.

But, although a company strives to match its production to true customer demand, a point will come where the variation in demand for individual products will mean that certain flow lines are under utilised while others are overburdened. At this point, mangers will need to reallocate resources quickly as demand changes. This calls for the ability to perform dynamic reconfigurations of the workloads among workstations within the cells. The objective is continuously to optimise system productivity to whatever the level of demand may be. Such a method relies on standardised work and highly skilled and adaptable workforce.

Step 4: Implement Supply Chain Co-ordination

As companies move to single-piece-flow, suppliers must be able to precisely sequence and deliver just-in-time components directly to their primes. The implications of supply disruptions due to poor quality, poor planning, or unplanned downtime, become therefore more acute. Supply chain co-ordination is essential to look at, and avoid these disruptions between companies. This type of co-ordination must involve areas such as working to common quality standards, using the same paperwork system, shared transport and employing inter-company communication methods such as EDI. The intention is to improve delivery

performance and lower costs. Specific techniques can include training, technical assistance, supply chain meetings, site visits and employee exchanges.

Step 5: Reduce Inventory Buffers

By streamlining the supply chain, a company can now reduce inventory buffers to the lowest level capable of maintaining flow. In this way the company frees up more cash, decrease costs, and improve profitability. The transition period for inventory reduction must be done gradually (in order to avoid potential disruption) and for greater improvements, there are four major things a company needs to have in place: (1) the ability to execute an inventory plan and all the support systems; (2) an inventory tracking and costing program; (3) a supply chain strategy at the highest decision-making levels; and (4) a supply chain design and inventory policy optimisation plans.

Step 6: Readjust Resources

Readjustment of resources may include the reassignment of people and the realignment of other resources in the organisation to create and maintain a better internal control structure and therefore build additional value in the organisation.

Because workers are an organisation's most valuable resource, the organisation should focus on them and on those activities where they add the most value. This means reassigning the trained and experienced people focusing them on other areas so they can coach and teach others about this new system. This must be done to the maximum extent possible. Just as people will need to be redeployed, so will other resources for continuing and improving the reform process.

4.2.5   Enterprise Use and Improvement (Strive for Perfection)

This stage consists on the operational use of the transformation and continued review for improvement or modification. The operation of the transformed system must ensure the continued strong centralised vision, transformation improvement goals, and progress measurement metrics that were designed in the earlier phases and steps.

The detailed planning and clear target setting that contributed to the implementation of Lean must become the norm rather than the exception. This means that mechanisms must be put in

place to refine the sequence of actions implemented taking the improvements to the next level.

The outputs from this stage may feed back into any and all other stages and phases as the Lean transition improves the competitive position of the operations system and the enterprise.

(The following actions might take place without a specific order, at any and at the numerous times concurrently with all the identified steps in the previous stages).

Action 1: Human Resource Development

In the larger context of fostering the company's long-term continuous improvement, develop the company's human resources should be considered as one of the ways. Human resource development is a process that benefits from itself (as illustrated in Figure 8), resulting in improved company competitiveness, which leads to a larger market share, which in turn, brings more revenues to the company – revenues that can be reinvested, in part, in improved training, increasing therefore the knowledge and skills of the employees, modifying their attitude, preparing and providing them with the means to embrace the needed changes. Top management should establish training programs according to its vision of what the company should be in the future.
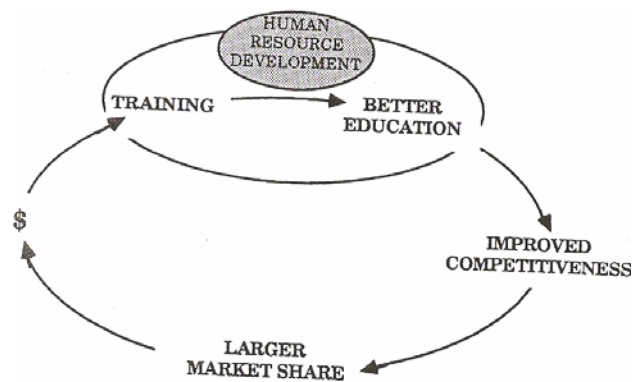

Figure 8: Training Cost-Benefits Cycle (Source: Steudel and Desruelle, 1992)

Action 2: Optimise Quality Management

Optimising quality management invariably results in achieving higher levels of business performance and maturity. A developed approach to quality optimisation should have at its foundation the following principles:

(1) Listening to the "voice of the customer": the first step in the quality effort must be to

understand the "Customer Critical to Quality Issues". Company targets for quality must be set to meet or exceed the customer requirements;

(2) The use of evidence based decision making instead of opinions: a quality focused organisation must support all opinions with data. Data helps focusing on customer requirements and measure the company capability to satisfy them;

(3) The strategic use of both "Results" and "Process" measurements: results measures must be customer focused. Continuous improvement will come from process measures. Measuring processes allows for base-lining current process capability, analysing improvement opportunities, establishing stretch improvement goals, quantifying improvements realised and controlling process variation. Six Sigma as one statistical measurement tool is one of the best practices to be applied. Proper application of Six Sigma principles has been proven to vastly improve infrastructure and application reliability, reduce errors in processing, improve user provisioning processes and drive toward 100% data accuracy.

(4) The use of "process speed" to respond to changing market trends and improve overall quality performance: "process speed" empowers the company to satisfy customer requirements, by reacting to customer change demand and identifying quality issues earlier and resolve them.

Action 3: Institutionalise Continuous Improvement Tools & Techniques: such as 5Ss and Kaisen Events

The need for regularly updating processes and key factors for a sustainable continuous process improvement calls for the company need to institutionalise 5Ss tools and Kaisen events in a daily basis, involving everyone in the organisation. The main theme for the enterprise is to create a strategy for never-ending efforts for improvement, largely by assigning responsibility to workers, and encouraging them on the identification and exploitation of new performance opportunities.

Action 4: Prepare for More Frequent and Stringent Product Launches

This step considers integrating engineering and manufacturing processes and systems to more effectively support Lean. The objective is to exploit the process data and knowledge developed in the Design and Implementation stages to facilitate process engineering design,

process portability, and reduced risk during pilot production and production ramp-ups. With the demand for more frequent product launches, it is expected a rapidly and seamlessly transition, and this requires an orchestration of the processes between engineering and manufacturing.

Action 5: Evaluate Results against Target Goals & Metrics

In this step the results obtained must be compared with the stated goals and metrics that were established in the preparation stage to challenge the Lean implementation, in order to evaluate the degree of success achieved by the enterprise in meeting these targets. Evaluation must be carried out in a continuous manner to provide assessment of the implementation, determining if mid-course corrections are required in light of the observed progress.

Evaluation of performance against established targets must be productive, rather than punitive, when the process of evaluation itself becomes a means for continuous improvement, through root cause analysis in areas where performance is found to be seriously deficient.

Action 6: Balance Long-term Strategy and Short-term Results

Although immediate results can be gained implementing Lean techniques in manufacturing, more dramatic and positive change happens only over-time with a multi-year commitment basis. Expectations regarding short-term results need to be therefore correctly managed.

Action 7: Evaluate Lean Maturity Progress

Assessing the organisation's operational Lean maturity level is essential to determine the current position and the target position. From this it is possible to identify gaps and weaknesses that need to be addressed to take the organisation into the next level of maturity.

One of the methods / tools to evaluate the level of the organisation's Lean maturity can be the use of the Lean Maturity Matrix developed by the MIT Institute in collaboration with the Northrop Grumman Corporation (see Table 5). The matrix utilises a grading scale according to the degree of Lean implementation on seven criteria: use of human resources, product definition, use of suppliers, quality practices, production control, business processes, and facilities & equipment. The scoring index for maturity starts at level 1 where an organisation is functional as mass production. The maturity moves then through the milestones of partly

Lean, generally Lean, etc, and finally onto level 5, the virtual enterprise. As the organisation learns, it becomes more able to develop more sophisticated approaches taking therefore the enterprise to a new level.

4.3 Synthesis

In this chapter a roadmap has been developed viewing Lean implementation enterprise-wide, and not incremental in one element or cell of the manufacturing process. It is believed that a silo view of Lean implementation may allow gaps in performance to persist. By employing the architecture of the roadmap it is expected to improve enterprise-wide quality, on time delivery, and customer satisfaction by eliminating waste in the entire organisation and supply chain.

Practice/Process	Level 1 *Functional* *as Mass Production*	Level 2 *Partly* *Lean*	Level 3 *Generally* *Lean*	Level 4 *Internally Lean,* *Partly Agile Externally*	Level 5 *Virtual* *Enterprise*
Use of Human Resources	Narrow job scopes. Strong functional dept boundaries.	Effective training with functional depts	Broad job scopes. Product-based teams across functions. HR policies support teams.	Easily reconfigurable organizations	HR policies support 'real' people working for multiple 'virtual companies'.
Product Definition	Paper drawings. Errors found through trial and error in tooling and production	Some use of CAD. Design includes producibility analysis.	3D digital design flowed to tooling and production. Variability simulation, electronic mockup. Designed in IPD teams.	Shared CAD data and design responsibility with customers and suppliers across many physical locations.	Complete transportability of technical data via industry data standards - PDES, STEP, etc.
Use of Suppliers	Price-based competition. Adversarial relationship	Technical interchange. Incentives for cost reduction and savings sharing	JIT delivery to point of use without receiving inspection. Tiering of suppliers by major commodity.	Sharing of schedule updates electronically	Suppliers identified and contracted quickly through standard contracts, etc.
Quality Practices	Quality improvement through volume learning. Inspect to find bad parts. Customer is final inspector.	Quality function deployment to flow customer rqmnts to product and process KCs	Effective process control and corrective action process. Production self inspects. Mistake proofing	Single quality (ISO based) system	
Production Control	Launch and expedite orders per standard breakbacks for contract lots. Large fabrication batch sizes.	Effective MRP system with finite capacity planning.	Small batches, use of internal pull system. Paperless access to all required information.	Use of pull system between customers and suppliers.	Linked control systems controls flow across several companies.
Business Processes	Separate business process for different customers, military vs. Commercial. Processes producer driven rather than customer. pulled.	Heavily interfaced systems.	Single processes for all customers. Heavily integrated systems.	Systems and processes integrated with customers and suppliers.	Contracting, Finance, etc. supports operation of multiple virtual companies.
Facilities and Equipment	Functional layout of processes. Immovable monuments. Excess space and overhead costs. Excess automation.	Effective preventative maintenance. Effective use of process technology.	Smaller, moveable equipment arranged into product flow. Low overhead cost.	Products flow cross company boundaries seamlessly. Equipment and facilities configurable.	Capacity known and managed for a virtual company across many 'real' companies.

Table 5: Manufacturing System Maturity Matrix (Source: MIT and Northrop Grumman Corporation, 2000)

5. CONCLUSIONS

Many organisations are attempting to implement Lean programs. Unfortunately, these organisations may fail to recognise that multiple variables contribute to a Lean implementation success or failure. This paper has described the realisation of critical success factors determining a successful implementation of an enterprise-wide Lean transformation in manufacturing environments. The identified critical success factors have provided a useful insight for the enhancement of critical decision-making process, needed for the development of a Lean manufacturing strategy and implementation plan.

5.1 Main Conclusions

The study has examined the typical approach taken by companies seeking to implement Lean principles and practices in their organisations to achieve a Lean transformation. Numerous misunderstandings about the Lean management system, including its intent and related nuances, where identified, which result in common implementation errors. These errors reveal much about the current state of understanding of Lean among these companies. In seeking to implement a Lean transformation, organisations must realise that they are embracing for the first time a principle-based system of management whose objective is to change the way all work activities are performed, not just those in operations.

Analysis from the research, together with evidence from literature, indicates that the major difficulties companies encounter in attempting to implement Lean are: (1) a lack of clear vision and strategy; (2) a failure to understand the scope of lean management system; (3) a lack of a structured methodology & project management; (4) a lack of management commitment and involvement; (5) a lack of a strong leadership; (6) a lack of a supportive human resources policy; (7) a lack of a supportive organisational culture based on sustainable proactive improvement; (8) a failure to engage employees & mobilise change champions; (9) an ineffective communication particularly across functional boundaries; (10) a failure to monitor and evaluate the outcome / poor metrics and (11) a failure to expand lean implementation to the supplier chain. Knowledge of particular tools and techniques is often not a problem.

Several elements are viewed indispensable hence critical to the successful implementation of enterprise-wide Lean transformation. The study presented in this paper emphasises that a clear vision and business director is fundamental for the success of the implementation. The

research found that by aligning Lean to more strategic aims of the business, more sustainable wins are made. This includes generating a vision of a fully integrated Lean organisation at the outset of implementation. Equally crucial is managerial commitment and leadership. The research indicates that there is a strong correlation between management engagement and Lean sustainability. The study also focuses on the importance of an adequate team and project management planning, training and communication plan across the enterprise. The capacity within the organisation to deal with change and an organisational culture, receptive to understanding the customer and the process analysis and able to use relevant data to drive improvement, are also considered key factors. Performance review and evaluation is also considered a critical success factor, based on the premise that the evaluation and performance monitoring of Lean system's implementation can in turn, lead to the achievement of all the business desired goal and objectives. Finally, the study has also suggested that for a Lean initiative to succeed it is vital to get the involvement of the supplier base.

All these factors are essential and therefore should be taken into account for optimising the financial return from Lean projects in all organisations. In order to achieve the full potential of Lean applications, it is important to take these factors into consideration. If any of these ingredients are missing during the implementation phase, it would be then the difference between a successful implementation and a complete waste of effort, time and money.

This paper provides also a roadmap for transitioning an existing manufacturing operations system to one that fully implements a Lean philosophy. The architecture uses systems engineering methodologies and lean principles to portray the overall flow of the action steps necessary to initiate, sustain, and continuously refine the entire enterprise. The architecture was developed from an enterprise perspective, paying particular attention to strategic issues and business viewpoints, human resources, internal and external relations with key stakeholders, and structural issues that must be addressed before and during a significant change initiative. It is not the purpose of the developed roadmap to be a "cookbook" of actions that must be strictly followed for every implementation. Rather, and because every organisation is unique by having its own culture, the various phases should be regarded as an appropriate guidance with checkpoints to ensure that the elements listed in the prior phase are in place or are being addressed, prior to proceeding to the next phase.

By tackling the barriers and ensuring the provision of the factors contributing to success, this research study provided answers to the following addressed research questions: 1) Why do so many companies fail in their Lean initiatives? 2) How to perform a Lean implementation in a

successful and sustainable way?

This study contributes thus, to the theory of Lean implementation and organisational change. For managers this study brings up important aspects for the management of change. First, realizing that performance effect of such system of management may take time to be realised, and persistence in implementation is crucial for the programme to become a success. Second the allocation of resources, approach and involvement have considerable influence on the outcome, and must be taken into consideration when such system is designed and performed.

5.2 Limitations

The present study has some limitations that restrict the generalisation of the findings. For one thing, it should be noted that the research is limited within the context of Lean implementation in manufacturing environments, and the results may not be applicable to other types of industry.

On the other hand, the three interviewed experts on Lean are only a small and limited sample based mostly on their experiences and memory. Although representing a wide range of perspectives, a larger number of participants would lead to a more concrete multi-variant analysis.

Another limitation of this study relates to the presented roadmap: applications and benefits are cited, but additional case studies are needed to test, evaluate and benchmark the performance of the roadmap against other Lean implementation approaches and methodologies. Therefore it should be treated with caution as indicative, but far from conclusive. Furthermore and again, the emphasis of the roadmap is on a set of management tools and techniques that are used in manufacturing environments. For other sectors or environments and in spite of the engagement with the principles of Lean, the implementation approach must certainly be adapted.

Further research spanning a wider range of contingencies, in particular industry type, company size, culture, and types, mix and innovativeness of action programmes, is needed to identify whether the findings reported in this study also hold in a broader setting.

5.3 Future Directions

One area is believed to have great importance for future work and therefore recommended for

future research: to look at how Lean value systems combined with a thoughtful application of Information Technology can help companies managing change and improve therefore business performance.

While early Lean adopters were pleased with the flexibility that paper and pencil provided, there have been a number of factors that are making "technology-less" implementations impractical for a number of reasons.

More frequent faster launches and additional variations to existing products, are driving the need to more quickly modify line design, simulate process flow, and re-optimise key control points (e.g. kanban sizes, supermarkets, Takt time) to ensure rapid and accurate changeovers and restarts. The importance of developing / maintaining a digital model of Lean processes will become increasingly critical.

In addition, IT solutions can play an important role in the daily operations of many Lean manufacturers, particularly in high-volume or highly complex production environments, through an integrated information system to manage processes of planning, scheduling, execution, control and decision making across the full spectrum of operations.

Information technology solutions can provide a solid foundation from which manufacturers can manage Lean transactions across core value streams that extend from the customer, through production, and back to the supplier.

REFERENCES & BIBLIOGRAPHY

A. References

Achanga, P., Shehab, E., Roy, E. and Nelder, G. (2006). Critical success factors for lean implementation within SMEs. Journal of Manufacturing Technology Management, 17(4), 460-471.

Backer, P. (2002). Why is lean so far off? Works Management, October, 26-29.

Ballard, G. and Howell, G.A. (2003). Lean project management. Building Research & Information, 31(2), 119-133.

Bayraktar, E., Jothishankar, M.C., Tatoglu, E., Wu, T. (2007). Evolution of operations management: past, present and future. Management Research News, 30(11), 843-871.

Benedetto, B. (2007). Thinking lean: technology can improve the performance of lean logistics in the supply chain. The Journal of Commerce, May, 20-22.

Bhasin, S. and Burcher, P. (2006). Lean viewed as a philosophy. Journal of Manufacturing Technology Management, 17(1), 56-72.

Boyer, M. and Sovilla, L. (2003). How to identify and remove the barriers for a successful lean implementation. Journal of Ship Production, 19(2), 116-120.

Bozdogan, K. (2006). A comparative review of lean thinking, six-sigma and related enterprise process improvement initiatives. Working Paper, supported by LAI (Lean Aerospace Initiative).

Bozdogan, K., Milauskas, R., Mize, J., Nightingale, D., Taneja, A. and Tonaszuck, D. (2000). Transitioning to a lean enterprise: a guide for leaders. MIT(Massachusetts Institute of Technology), Volume I.

Cagliano, R., Caniato, F. and Spina, G. (2006). The linkage between supply chain integration and manufacturing improvement programmes. International Journal of Operations & Production Management, 26(3), 282-299.

Coronado, R.B. and Antony, J. (2002). Critical success factors for the successful implementation of six-sigma projects in organisations. The TQM MAGAZINE, 14(2), 92-99.

Drew, J., McCallum, B. and Roggenhofer, S. (2004). Journey to lean: making operational change stick. Published by PALGRAVE MACMILLAN, New York.

Emiliani, M.L. and Stec, D.J. (2005). Leaders lost in transformation. Leadership & Organisation Development Journal, 26(5), 370-387.

Engineering Employers' Federation (2001). Catching up with uncle Sam: the EEF final report on US and UK manufacturing productivity. December, 4-41.

Feld, William M. (2001). Lean manufacturing: tools, techniques and how to use them. St. Lucie Press.

Forza, C. (1996). Work organisation in lean production and traditional plants. International Journal of Operations & Production Management, 16(2), 46-62.

Hines, P., Holweg, M. and Rich, N. (2004). Learning to Evolve: a review of contemporary lean thinking. International Journal of Operations & Production Management, 24(10), 994-1011.

Hines, P., Francis, M. and Found, P. (2006). Towards lean product lifecycle management: a framework for new product development. Journal of Manufacturing Technology Management, 17(7), 866-887.

Hines, P., Found, P., Griffiths, G. and Harrison, R. (2008). Staying Lean: thriving, not just surviving. Published by: Lean Enterprise Research Centre, Cardiff University and Cardiff Business Technology Centre.

Karlsson, C. (1992). Knowledge and material flow in future industrial networks. International Journal of Operations & Production Management, 12(7), 10-23.

Karlsson, C. and Ahlström, P. (1996). Assessing changes towards lean production. International Journal of Operations & Production Management, 16, 2-11.

Karlsson, C. and Ahlström, P. (1997). A lean and global smaller firm? International Journal of Operations & Production Management, 17(10), 940-952.

Kilpatrick, J. (2003). Lean Principles. Utah manufacturing extension partnership. Utah.

Kilpatrick, J. and Osborne, R. (2006). Lean Evolves: The Next R(E)volution. Business Breakthroughs Inc, 1-9.

Kotter, J.P. (1995). Leading change: why transformation efforts fail. Harvard Business Review, March-April 1995.

Krizner, K. (2001). Manufacturers adopt a lean philosophy. Frontline Solutions, July, 1-5.

Landsbergis, P.A. and Cahill, J. (1999). The impact of lean production and related new systems of work organisation on worker health. Journal of Occupational Health Psychology, 4(2), 108-130.

Larry, D. Alexander (1985). Successfully implementing strategic decisions. Long Range Planning, 18(3), 91-97.

Laugen, B.T. and Boer, H. (2007). The implementation of best practices: process and performance effects. Creativity and Innovation Management, 16(4), 397-407.

Liker, J. (2003). The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer. McGraw-Hill, New York.

Lucey, J., Bateman, N. and Hines, P. (2005). Why major lean transitions have not been sustained. Management Services, 9-13.

Mathaisel, Dennis F.X. (2005). A lean architecture for transforming the aerospace maintenance, repair and overhaul (MRO) enterprise. International Journal of Productivity and Performance Management, 54(8), 623-644.

McKone, K.E., Schroeder, R.G. and Cua, K.O. (1999). Total productive maintenance: a contextual view. Journal of Operations Management, 17, 123-144.

Moore, R. (2001). Comparing the major manufacturing improvement methods. Plant Engineering, September.

Nash, M. and Poling, S. R. (2007). Strategic Management of Lean. Quality Management, April, 46-49.

Ohno, Taiichi (1988). Toyota Production System: Beyond Large-Scale Production. Productivity Press, Portland, Oregon.

Padgett, A. (2004). Why lean implementations fail. Gordian Transformation Partners Inc., Atlanta.

Papadopoulou, T.C. and Özbayrak, M. (2005). Leanness: experiences from the journey to date. Journal of Manufacturing Technology Management, 16(7), 784-807.

Swank, C.K. (2003). The lean service machine. Harvard Business Review, 81(10), 123-129.

Tracey, Monica W. and Flinchbaugh, J. (2006). HR's role in the lean organisational journey. WORLDATWORK Journal, Fourth Quarter, 49-58.

Womack, J.P., Jones, D.T. and Roos, D. (1990). The Machine that Changed the World. Rawson Associates, New York, NY.

Womack, J.P. and Jones, D.T. (1994). From lean production to the lean enterprise. Harvard Business Review, March-April, 93-103.

Womack, J.P. and Jones, D.T. (2003). Lean Thinking: banish waste and create wealth in your corporation. Simon and Schuster, London.

Worley, J.M. and Doolen, T.L. (2006). The role of communication and management support in a lean manufacturing implementation. Management Decision, 44(2), 228-245.

Yin, R.K. (1994). Case study research: design and methods. 2nd Edition, Thousand Oaks: Sage

B. Bibliography

Aberdeen Group (2006). The lean benchmark report: closing the reality gap. March 2006.

Aberdeen Group (2006). The lean supply chain report: lean concepts transcend manufacturing through the supply chain. September 2006.

Aberdeen Group (2007). Lean transformation strategies for the global enterprise. August 2007.

4. Alukal, G. (2003). Create a lean, mean machine. Quality Progress, April, 29-35.

Bozdogan, K., Milauskas, R., Mize, J., Nightingale, D., Taneja, A. and Tonaszuck, D. (2000). Transitioning to a lean enterprise: a guide for leaders. MIT(Massachusetts Institute of Technology), Volume II and III.

Crabill, J. *et al.* (2000). Production operations level transition-to-lean roadmap. Massachusetts Institute of Technology (MIT).

Fathollah, M. and Shafia, M.A. (2006). Becoming lean through the common platform in manufacturing. The International Journal of Applied Management and Technology, 4(2), 47-61.

Hines, P. and Taylor, D. (2000). Going Lean. Published by Lean Enterprise Research Centre and Cardiff Business School, UK.

Mortimer, A. Lee (2006). A lean route to manufacturing survival. Assembly Automation, 26(4), 265-272.

Steudel, H. J. and Desruelle, P. (1992). Manufacturing in the nineties: how to become a mean, lean, world-class competitor, VNR Competitive Manufacturing Series.

Todd, P. (2000). Building the lean machine. Advanced Manufacturing, January, 21-26.

Websites

Lean Affiliates Website, at http://www.leanaffiliates.com/

Lean Aerospace Initiative (LAI), Massachusetts Institute of Technology, at web.mit.edu/lean/

Lean Enterprise Institute (LEI) Website, at http://www.lean.org/

Lean Enterprise Research Centre (LERC) Website, at http://www.leanenterprise.org.uk/

APPENDIX 1: GLOSSARY OF KEY TERMS AND DEFINITIONS

(Key terms associated to Lean and used on this paper are defined below).

Agile (Manufacturing)   Agile Manufacturing is presented not as a component of Lean but for completeness as often Lean and Agile are presented in documents and writing together i.e. "Lean and Agile". However, it is important to realise that Agile is not the same as Lean. Agile can be seen as the principles of Lean combined with Flexible Manufacturing Systems (FMS) to provide low-cost manufacturing through application of processes, techniques and people.

Batch   A lot or given quantity processed at the same time with the same process parameters. A batch may consist of more than one item number but all items are considered to have the same characteristics for purposes of traceability.

Batch and queue   The mass production process of making large lots of a part and then sending the batch to wait in the queue until the next operation in the production process begins. Contrast with one-piece flow.

Benchmarking   The practice of establishing goals and targets for process performance levels and identifying required improvement areas based on the published or known performance of direct competitors or a relevant industry. Comparing key performance metrics with other organisations in similar or relevant industries. Establishing standards for improvement based on what others have been able to achieve.

Cell   An arrangement of machinery, tools, and personnel designed to most logically and efficiently complete a production sequence. Cells help enable one-piece flow.

Cellular Manufacturing   An approach in where manufacturing work centres (cells) have the total capabilities needed to produce an item or group of similar items; contrasts to setting up work centres on the basis of similar equipment or capabilities, in which case items must move among multiple work centres before they are completed.

Changeover Time   The time that elapses between the completion of one production run and the beginning of the next production run.

Cycle Time   The amount of time to accomplish the standard work sequence for one product, excluding (wait) time. If the cycle time for every operation in a complete process can be reduced to equal takt time, products can be made in one-piece flow.

EDI   Electronic Data Interchange – The electronic transfer of order and transfer information between trading partners on the same system, that uses a predefined, standard message format for order receipt, order release, advanced shipping notifications, invoices and

other transactions.

5S   5S represents five Japanese related terms, describing workplace practices conductive to visual control and Lean production. The five terms in Japanese are: *Seiri* (organisation), *Seiton* (neatness), *Seiso* (cleaning), *Seiketsu* (standardisation), and *Shitsuke* (discipline).

Full Implementation   The adoption of Lean across the entire organisation, to the extent that Lean practices become the norm. The process requires an integration of Lean with organisation strategy, usually achieved through a process of policy deployment. The timing, sequence and coordination of implementation activities are carefully planned to achieve the primary objective of a fully embedded Lean approach. Shorter-term targets take a secondary role.

Just-in-Time   JIT is a production manufacturing concept that seeks to produce only what is needed, when is needed. Among other areas, it focuses on the reduction of lead-times, small lot sizes, flexible production facilities and workforces, elimination of quality defects, and the reduction of inventory levels to as close to zero as possible. The roots of JIT extend deep into Japanese cultural, geographic, and economic history.

Kaizen   Taken from the Japanese words Kai and Zen, where Kai means change and Zen means good. The popular meaning is continual improvement, typically achieved through incremental improvements and involving everyone from top management to supervisors and workers. The underlying assumption is small improvements, continuously made to a process, will lead to significant positive change over time.

Make/buy analysis   The process that analyses tradeoffs in costs and benefits between internal production of a given item vs. purchasing it from a vendor. It includes identification of true product costs, the impact of fixed overhead, facility capacity considerations, vendor capability and stability and other factors.

Muda   The Japanese term for waste - see 'waste' below.

One-Piece Flow   One piece flow production is when parts are made one at a time and passed on the next process. Among the benefits of one-piece flow are: 1) the quick detection of defects to prevent a large batch of defects, 2) short lead-times of production, 3) reduce material and inventory costs, and 4) design of equipment and workstations of minimal size.

Pull Production System   A production system in which nothing is produced by the upstream supplier until a need is signalled by the downstream customer; the opposite of push. The pull system links accurate information with the process to minimise overproduction.

QFD   Quality Function Deployment – An overall methodology that begins in the the design process and attempts to map the customer defined expectation and definition of quality into the processes and parameters that will fulfil them. It integrates customer interview and market research techniques with internal cross-functional evaluations of the requirements.

Right-Sized   The matching of production tooling and equipment in a scale that enables its use in the direct flow of products such that no unnecessary transport or waiting is required.

Six-Sigma   A quality measure and improvement program developed by Motorola that focuses on the control of a process to the point of +/- six sigma (standard deviations) from a centreline, or 3.4 defects per million items. It includes identifying factors critical to quality as determined by the customer, reducing process variation and improving capabilities, increasing stability and designing systems to support the six sigma goal.

SMED   Single Minute Exchange of Dies – The reduction in die set-up time.

SPC   Statistical Process Control – The use of statistical techniques such as Control Charts to analyse a process or its output to take appropriate actions to achieve and maintain a state of statistical control and to improve the capability of the process.

Supermarket   The supermarket is a tool of the pull system that helps signal demand for the product. In a supermarket, a fixed amount of raw material, work in process, or finished material is kept as a buffer to schedule variability or an incapable process. A supermarket is typically located at the end of a production line (or the entrance of a u-shaped flow line).

Takt Time   Based on the German word that indicates pace, the rate or pace of production as matched to the pace of customer sales. Used in Lean manufacturing to align production time in linked manufacturing processes.

Value-added Concept To be a value added process activity the activity must meet all three of the following criteria: 1) the customer is willing to pay for this activity, 2) it must be done right the first time, and 3) the activity must somehow change the product or service in some manner.

Value Stream   It represents the chain of activities and processes by which value is added to input resulting in the delivery of products and services to customers.

Value Stream Mapping A diagram technique used in Lean manufacturing that maps every step involved in the material and information flows needed to bring a product from order to delivery. The first step is to draw a visual representation of every step in a process, including key data, such as the customer demand rate, quality, and machine reliability. Next, draw an improved future-state map showing how the product or service could flow if the

steps that add no value were eliminated.

Waste Any activity that consumes resources but creates no value for the customer. To eliminate waste, it is important to understand exactly what waste is and where it exists. Toyota, the originator of the JIT concept, identified seven possible sources of waste typically found in manufacturing environments: 1) Overproduction: producing too much, too early; the worst form of waste because it contributes to the other six; 2) Inventory: having more than the minimum stocks necessary for a precisely controlled pull system; 3) Conveyance: moving parts and products unnecessarily; 4) Processing: unnecessary processing steps, typically from poor tool or product design; 5) Defects: parts need rework or are scrap; 6) Motion: unnecessary worker movements; 7) Waiting: involves periods of inactivity for people and product.

APPENDIX 2: INTERVIEW DEVELOPMENT AND ADMINISTRATION

The interview process is part of a larger investigation on the evaluation of the critical success factors in the full implementation (not Rapid Improvement Event or "Kaizen Blitz") of a Lean transformation in manufacturing environments. The goal is to collect data from experts' views in their field work attempts at Lean transformations that ultimately support the findings found in the critical review of literature.

Interview Script Development

The first step in developing the interview script was an extensive review of existing research in an effort to identify variables and factors relating to Lean full implementation challenges. Upon completion of this review, it has been determined that four topic headings were of particular importance and should be investigated further through interviews. These topic headings include:

- **Contextual Factors and Organisational Strategy**: this section searches to identify both the internal and external factors and drivers that can influence an organisation's decision to engage in adopting the Lean paradigm. This section searches also to examine the role of the strategy as a key driver for linking Lean to effective and sustainable improvement;

- **Organisational Readiness for Improvement Transformation**: this section searches to identify the factors which affect the ability of an organisation to implement an effective Lean transformation;

- **Implementation Process and Outcomes of Lean**: this section searches to identify and outline key guidance features to the implementation process from relevant insights and recommendations given regarding the programme methodology, the appropriate objective-setting mechanisms and metrics evaluation. There maybe some overlap with Organisational Readiness section above.

- **Critical Failure Reasons in Implementing Lean**: in order to learn from past failures, this section searches to determine which implementation failure reasons occurred most frequently and are more critical as the organisations tried to implement Lean and the strategies to overcome them.

Administration

The individuals interviewed were sent an email with a general description of the study, and soliciting their participation. The interviews were semi-structured, divided into key topic headings, with key questions to be asked. The interviews were conducted during July and August 2008. Notes were taken of all interviews and most were recorded on digital audio and then transcribed so a full record could be available.

Summary of Participants

Management Consultant, Consultant at an independent worldwide consultancy organisation, committed to provide consulting services to companies, of all sizes and industrial segments as well as private public service organisations, represented in Europe, Asia, Africa and America.

Academic, Associate Professor at the Department of Industrial Engineering and Management at the Engineering University of Porto. His PhD consisted in the reliability of the information systems of the manufacturing facilities of a European Auto Manufacturer (Renault). His main research interests are in the areas of quality management and engineering production systems with a focus on the simulation of Lean production systems

Lean Manager, at Bosch Termotecnologia SA. Bosch designs, manufactures and sells its products throughout the world from 250 manufacturing sites in 90 countries. With half its 230 000 workforce outside Germany, Bosch is a global player. Its three business sectors create products ranging from car components; capital goods like packaging and locomotive technology to household appliances.

INTERVIEW SCHEDULE

(Evaluation of Lean Implementation Challenges in Manufacturing Environments)

Location:

Name:

Job Title:

Organisation:

Date:

Introduction

Thank you for agreeing to take part in this research that I am conducting as a part of my MSc thesis at the Faculty of Engineering University of Porto (FEUP). The aim of the research is to identify and evaluate the critical success factors in the full implementation of a Lean transformation in manufacturing environments. I am especially interested in your perceptions as it relates to instituting the best practices in Lean projects and their sustainability. I am looking at both the content of which implementation problems you have found and the strategies you have applied to overcome these problems.

The interview includes questions designed to determine the following:

- What is driving manufacturers today to adopt Lean? What are their business needs and expectations?

- How are "best-in-class" implementing Lean? What are their critical success factors and how are these being measured?

- What tools, techniques, and technology solutions are leaders using to deploy and scale their Lean operations?

Area Investigated	Focus of Area	Questions
1. Perceptions of Lean (Concern: There are many views of what constitutes "Lean". Although most people recognise the roots of Lean in the Toyota production system, there has been considerable development of the concept over time.)	This section focuses on how they define and consider Lean and what they think the organisations should do related to it.	1) How do you define the term "Lean" / "kaizen" / "systems improvement"? 2) Which elements of the concept are most important for you? 3) Which aspects of Lean do you think have been focused and tried within the projects you have been involved? 4) Were the Lean projects seen as a short-term or developmental process?
2. Contextual Factors (Concern: Companies adopt Lean for a variety of reasons. It is apparent in the literature case studies examples that there are internal and external drivers which are reported to have influence on organisation's decision to adopt Lean. In some cases it is possible to isolate a single driver, more often there is a more complex picture.)	This section focuses on the organisational context, history and structure relating to Lean projects and initiatives.	5) What is driving manufacturers today to adopt Lean? What are their business needs and expectations? 6) Are there any critical incidents or crises that "spark" the change? (Because there's a clear relationship between the pressures companies identify, the actions they take, and their subsequent competitive performance).

3. Organisational Strategy (Concern: Literature review suggests that for Lean or improvement to be sustained the objectives of the programme should be integrated and linked into the strategy of the organisation. Having a clear relationship between strategy and Lean can help drive organisation performance. However it is perceived that there is a weak connection between the two. In order to understand if the Lean programmes have been considered within the context of an overall strategy it is important to ask the interviewees about their strategy process field experiences.)	This section focuses on the organisations understanding, awareness, approach and process of developing a Lean strategy.	7) How would you describe the organisations approach to strategy? 8) How well developed are the organisations in terms of their work on strategy? (Realistic objectives, timescales, policy deployment…) 9) Are there any links between the strategy and Lean initiatives? 10) How can organisations align their Lean activities with their business objectives? 11) Do Lean programmes have a larger scale programme where methodology, strategy or objectives are "given"? 12) Is there a defined "Operations strategy"? 13) Who is involved in strategy? Have the stakeholders been involved? 14) Could you describe an "ideal" strategic planning process for Lean implementation?

4. Organisational Readiness (Concern: Organisational readiness is a mix of many factors, including the acceptance of the need to change and the ability to develop a change capability. According to literature, some sites are potentially unsuitable for Lean if the organisation is not in state of readiness for Lean – Examples: (1) sub-optimal department working; (2) sub-optimal top-down management style; (3) potential union resistance; etc. This concept became therefore of particular relevance and importance within the research as the degree to which the organisation is ready appears to have impact on its ability to engage with Lean which, in turn, impacts upon outputs.)	This section focuses on the extent which the people in the organisations and the organisations themselves understand and are aware of the necessity of getting the "basics" right first, before launching a Lean transformation.	15) What do employees and managers perceive are the specific conditions needed to implement a Lean transformation? 16) In your opinion what are the factors that support organisations in their attempts at Lean transformations? (What factors are relevant to the development of readiness for Lean?) 17) What strategies should be used to engage staff in the Lean transformation? 18) What tools, techniques, and technology solutions are "best-in-class" using to deploy and scale their Lean operations?
5. Implementation Process (Concern: to have a better understanding of the organisational implementation issues of such a major change programme.)	This section focuses on identifying organisational implementation issues, such as timing, resources, sequence and coordination of implementation activities.	19) Who should be involved in providing the training and development for the Lean projects? 20) What timescales are involved? What is an aggressive yet reasonable timeline for Lean implementation? 21) What resources are needed? 22) How resource intensive cans implementation be for both participants' time and central support? What are the other resource implications? 23) Can you describe the project sequence implementation that should takes place? Should it begin across the entire enterprise, or target specific value streams in phases?

6. Outputs and Outcomes (Concern: the test for any new management concept is whether or not the outcomes of the approach are sufficient to justify the cost and effort of the implementation. It is the intent of the researcher to explore how outcomes are setting in the implementation phase, to understand the appropriate mechanisms for determining objective-setting and the metrics associated.)	This section focuses on the outputs and outcomes of the Lean projects.	24) What outcomes should usually be set for the project at the start? 25) How can these outcomes been measured? How are metrics defined and calculated? 26) Within the projects you have been involved, are the changes been sustainable? How? (Have some changes showed initial success and then faded?) 27) Would you say that these changes addressed strategic performance, e.g. speed, quality, etc? How? 28) How can a Lean project affect the rest of the organisation? Are there hidden benefits?
7. Critical Failure Reasons in Implementing Lean (Concern: research demonstrates that not all Lean projects succeed as they should and that there can be practical difficulties / barriers within the organisation conducting to Lean implementation failure.)	This section focuses on identifying the top reasons why major Lean change transformations might fail. The objective is to compare and contrast the literature findings with the interviewees' point of view, in an effort to get a balanced view, to develop a successful change strategy. They are evaluated on five levels criteria: strategic, managerial, structural, organisational and operational.	29) Based on your both success and failure experiences, could you rank-scale in order of critical importance the following possible reasons for failure in the implementation of Lean? (See Table…) 30) Is there in your opinion any additional important reason that has not been covered?
31) Is there anything else that has not been covered above that you wish to add about Lean implementation challenges?		

Table: Reasons for Failure

Reasons for Failure	Importance (1=Low, 9=High)								
	1	2	3	4	5	6	7	8	9
Strategic Level:									
1. Lack of a clear vision and strategy									
2. Lack of an effective communication strategy									
3. Failure to create a sense of urgency									
4. Failure to understand the scope of lean management system									
Managerial Level:									
5. Lack of a structured methodology & project management									
6. Lack of management ability to operate in diverse environment									
7. Poor cost and schedule estimation and planning									
8. Poor consultation with all stakeholders									
9. Lack of management commitment and involvement									
10. Lack of strong leadership									
11. Management turnover									
Structural Level:									
12. Lack of adequate financial funding									
13. Lack of enough skills and expertise									
14. Absence of a dedicated and fully resourced implementation team									
15. Lack of a supportive human resources policy									
Organisational Level:									
16. Lack of a supportive organisational culture based on sustainable proactive improvement									
17. Failure to engage employees & mobilise change champions									
18. Lack of cross-functional participation									
19. Ineffective communication particularly across functional boundaries									
Operational Level:									
20. Lack of standardised mechanism of analysis and measure of value adding capabilities within organisations									
21. Resistance to change from supervision and workforce									
22. Failure to monitor and evaluate the outcome / Poor metrics									
23. Complexity and high level of work involved									
24. Not enough training									
25. Not able to sustain initial efforts									
26. Not expanding improvement from the initial efforts to other departments									
27. Improvements in one area seemed to have negative impacts in others									
28. Failure to expand lean implementation to the supply chain									