A Framework for Lean Implementation: Lessons from Grundfos Manufacturing Hungary

Theoretical framework extended by findings from a case study of a lean implementation project in Grundfos Manufacturing Hungary

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Abstract:

The purpose of this research was to investigate how the implementation of lean production can be effectively planned and managed. Based on a literature review of the existing literature on lean, change management and lean implementation, a comprehensive framework for lean implementation which considers the technical, organizational and change management aspects of lean implementation was developed. Four significant elements of this framework were chosen for further investigation. These elements concerned the importance of top management support and active leadership, basic operational stability, a culture for problem solving and continuous improvement, and lean knowledge and training, to a succesful lean implementation. Four propositions to guide the research were formulated based on these elements. A case study of a lean implementation project in Grundfos Manufacturing Hungary was conducted to test the propositions. The case study confirmed the importance of the four elements, as well as the importance of availability of resources and realistic and strategic goalsetting, to lean implementation success. A revised framework based on the case study findings was presented.

Preface

This is the Master's Thesis of Peter Maarbjerg Buus, presented to Aalborg University as partial fulfillment of the requirements for obtaining the Master's Degree in International Technology Management. This thesis has been written under the supervision of Sami Farooq, Assistant Professor at Center for Industrial Production, Aalborg University.

This Masters thesis was developed based on my experiences during my half year internship at Grundfos Manufacturing Hungary. I would like to extend my thanks to my former colleagues in the GSE team in Grundfos Manufacturing Hungary. They were very forthcoming, helpful and great to be around, and made my stay in the company a very enjoyable experience. I am also very thankful of their help during the process of writing my thesis.

I must also express my extreme gratitude towards the consultants from the lean consultancy company that participated in the second phase of the lean implementation project. Working with them, observing them and learning from them greatly deepened my understanding of lean, and provided me with the inspiration for writing this thesis.

Lastly I would like to thank my supervisor, Sami Farooq. I realize that I am not the easiest of students to supervise, and I much appreciate his patience with me and his advice and support particularly during the last few very tough weeks of the process.

Peter Maarbjerg Buus

Contents

CHAPTER 1

Introduction

1.1 Introduction

Ever since the establishment of operations management as an academic field in the 19th century, it has concerned itself with how to improve the effectiveness and efficiency of manufacturing operations (Sprague, 2007). The attention given to the importance of effective operations management has only increased since manufacturing was recognized as a legitimate source of competitive advantage in the second half of the 20th century. Out of the many different production philosophies available, lean production as invented by Toyota and popularized by Womack *et al.* (1990) has been one of the most popular (Pavnaskar *et al.*, 2003; Jørgensen *et al.*, 2007; Worley and Doolen, 2006). Lean production has been shown to provide strong benefits in many different industries (Sohal and Egglestone, 1994; Shah and Ward, 2007). With the ever increasing levels of global competition, lean production's emphasis on waste reduction and value creation has become ever more appealing to companies as they seek to gain the most from their manufacturing operations (Scherrer-Rathje *et al.*, 2009). While lean has its critics, its ability to provide high performance and a competitive advantage is well accepted amongst operations management academics and practitioners alike. Even the critics of lean production concede that no alternatives have found the same amount of popularity or success, and that lean looks to become the standard manufacturing mode for the 21st century (Shah and Ward, 2007). For this reason, it has continued to be a popular and important topic within operations management literature (Pilkington and Fitzgerald, 2006; Taylor and Taylor, 2009).

However, while the ability of lean production to provide great benefits and be a source of competitive advantage is well-known, truly successful applications of lean production in the Western world have been few and far between (Spear and Bowen, 1999; Worley and Doolen, 2006). According to Liker and Rother (2011), a large survey of US manufacturing companies conducted by the magazine *Industry Week* in 2007 found that a mere two percent of companies with a lean program have achieved the expected results. Indeed, Stamm (2004) argues that: *"There are more companies that believe they have implemented lean than there are companies that have really implemented lean."* Tracey and Flinchbaugh (2006) also contend that while 'going lean' may be a powerful means to improve a business, too few organizations are able to successfully do so. There are many theories about why this is the case.

Some argue that companies lack understanding of the real purpose and complex synergies between the lean tools (Shingo, 1989; Pavnaskar *et al.*, 2003). Others argue that for lean to succeed, a lean culture must be implemented (Liker, 2004; Ballé, 2005; Atkinson, 2010). Yet again others argue that the challenge lies in successfully managing the change process (Smeds, 1994; Nordin *et al.*, 2008). The common theme is that the implementation of lean is difficult and challenging, and that few companies succeed in transitioning from a traditional mass manufacturing system to true lean production.

While attempts have been made to create a useful framework for lean implementation, none of the existing frameworks include all the relevant perspectives mentioned above. This research seeks to fill this gap in the literature by synthesizing the existing literature on lean and its implementation into a comprehensive framework for lean implementation. This framework considers both the technical elements and tools of lean, its organizational elements, the change management process, and the sequence in which the different elements should be implemented. This research further investigates four key elements of the framework by means of a case study of a lean implementation project in the company Grundfos Manufacturing Hungary. Based on the findings from the case study, the framework is revised and a refined framework is presented.

1.2 Research Question

The research question guiding this research is:

> *How can the implementation of lean production be effectively planned and managed?*

1.3 Research Objectives

This research has three main objectives:

1. To develop a framework for the effective implementation of lean production which considers both technical, organizational and change management aspects.

2. To refine this framework using a case study.

3. To provide examples of how to operationalize the framework.

1.4 Scope of Research

The scope of this research is limited primarily in three ways:

- The research considers the implementation of lean production in manufacturing operations only and thus delimits itself from discussing the application of lean in a service environment or in other parts of the value stream such as product development.

- The scope is limited to the implementation of lean production in a single company.

- The initial framework is based on the existing body of literature on lean production and change management.

1.5 Primary Contributions

The main contributions from this research are:

- Academically the research offers a comprehensive, holistic framework for lean implementation which recognizes the major perspectives on lean implementation existing in the literature, and thus contributes to the existing body of literature on lean implementation.
- Practically the research provides a guiding framework for managers seeking to implement lean production as well as examples of practical tools and techniques for operationalizing key elements of the framework.

1.6 Research Process

In order to answer the research question, a literature review of lean, change management and existing lean implementation frameworks was conducted. Based on this literature review, several gaps in the existing literature were identified, and a comprehensive framework for lean implementation was developed. As it was beyond the scope of the research to truly test the framework, four propositions were developed which concerned key elements of the framework. These were:

1. Unambiguous management support from the beginning as well as active leadership throughout the implementation process is necessary for a successful lean implementation.
2. Establishing basic operational stability is a prerequisite for the implementation of the more advanced technical elements of lean.
3. A culture for waste reduction through continuous improvement and problem solving should be established early on in the lean implementation process.
4. For a lean implementation to succeed, a critical mass of lean knowledge, both theoretical and practical, must be present from the outset, and training which is in correspondence with the elements being implemented must be provided.

These propositions were investigated based on an analysis of a case study of a lean implementation project in Grundfos Manufacturing Hungary. Based on the findings, the original framework was revised and a final framework presented.

1.7 Structure of Thesis

This thesis consists of seven chapters. The structure of the thesis is illustrated in figure 1.1.

- Chapter 1 provides an introduction to the thesis and the topic under study, and outlines the research questions, research objectives, and the scope and contributions of this thesis.
- Chapter 2 reviews the existing literature on lean and change management. Four lean implementation frameworks are reviewed, and the gaps in these frameworks are identified.
- Chapter 3 describes and explains the choice of research method, and presents the research design of this research.

- Chapter 4 provides a comprehensive lean implementation framework and explains its dimensions, phases and individual elements. Four propositions based on important elements of the framework are formulated to guide the case study research.
- Chapter 5 introduces the case of Grundfos Manufacturing Hungary, and describes the project to implement lean on a major production line in detail.
- Chapter 6 analyses the case of Grundfos Manufacturing Hungary based on the four propositions formulated to guide the case study. Additional findings and rival theories are also investigated.
- Chapter 7 provides a modification of the lean implementation framework based on the findings from the case study. The chapter also discusses the academic and practical contributions from the research, the generalizeability of the framework and the findings from the case, the weaknesses of this research, and potential directions for future research.
- Chapter 8 concludes the thesis by summarizing the findings from this research.

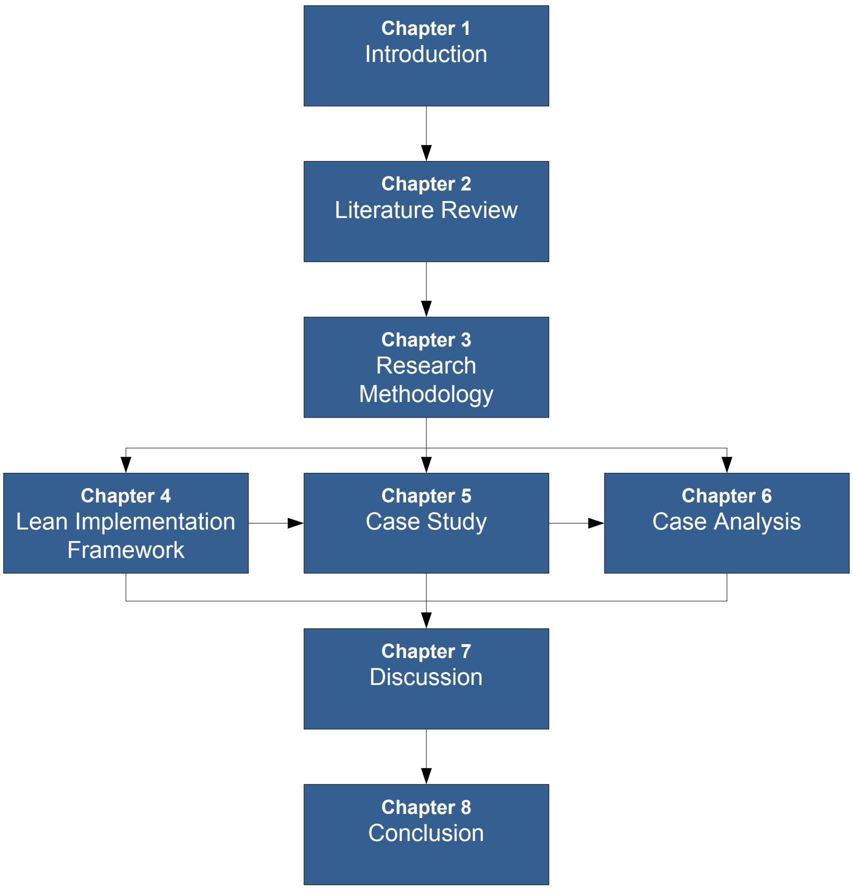


Figure 1.1: Thesis structure.

CHAPTER 2

Literature Review

2.1 Introduction

This chapter offers a review of the existing literature on lean, change management, and lean implementation frameworks. The background of lean is introduced, the concept is defined, and the system and its elements are reviewed and discussed. Briefly, the benefits and limitations of lean production are reviewed. The concept of change management is introduced and discussed from the perspective of lean production. Finally, four frameworks for lean implementation are reviewed. The chapter concludes with a discussion of the shortcomings of the existing literature on lean implemenation, and identifies the most significant gaps in the literature.

2.2 Lean Production

The term 'lean' is attributed to the researchers in the International Motor Vehicle Program (IMVP) at Massachusets Insititute of Technology. In the late 1980s, the IMVP set out to describe, measure, and explain the gap in performance between manufacturing in Japan and the West through a benchmarking study of 90 automotive plants from across the world. These studies discovered a major gap in performance and practices between Western automotive companies and Japanese companies, especially the Toyota Motor Corporation. The term 'lean' was then coined by Krafcik (1988) as he sought to describe the conceptual difference between the 'buffered' production systems of Western automotive manufacturers with their large in-process inventories, and the 'lean' Toyota Production System (TPS), which operated with little to no inventory. The term, and the manufacturing practices of Toyota, were later popularized in the Western world by Womack *et al.* (1990). Thus, 'lean production' is the term by which the majority of the Western world came to know the practices of the Toyota Production System.

The Toyota Production System was developed over several decades by two individuals in particular: Taiichi Ohno, who begun developing the system while managing an engine machine shop in Toyota in 1948 and since advanced to become Vice-President, and Shigeo Shingo, an industrial engineer who worked as a consultant with Toyota from 1955.

Both have published books about TPS, most notably Ohno (1988) and Shingo (1989). In these books, Ohno and Shingo describe the main objective of TPS as absolute elimination of waste. They also describe and explain the main techniques and tools of TPS. One of the pillars of TPS is Just-in-Time (JIT), which means that each process must be supplied with the required items, in the required quantity, and at the required time. This is achieved through small-lot production made possible by the use of techniques such as *heijunka* (levelling the production schedule), pull production using *kanban*, and rapid changeovers using the Single-Minute Exchange of Die (SMED) system. The other pillar is *jidoka*, or 'autonomation', which is the separation of man from machine through such methods as *poka-yoke* (error-proofing), and *andon* (visual control).

Since the 1980s, lean production has been a hot topic within operations management (Taylor and Taylor, 2009). While the literature of the 1980s focused on the shop floor tools and practices of Toyota, the literature of 1990-2010, while still placing the larger emphasis on the tools and techniques, broadened the concept in scope. Rather than being confined to the shop floor and manufacturing operations, it extended into supply chain management (Liker, 2004) and the rest of the value stream (Womack and Jones, 1996). A second aspect of lean also begun receiving increasing attention, namely the organizational aspect which placed an emphasis on people and culture as being important elements of a lean organization (Liker, 2004).

2.2.1 Definition

Much ambiguity exists concerning a precise definition of lean production. There are three different reasons for this. Firstly, TPS and, by extension, lean, was gradually developed within Toyota over a period of 30 years before the first descriptions of the system were available in English. Because of this, it was difficult for people at Toyota to describe in words what it actually was that they did differently, since it was just the way they had always worked (Holweg, 2007). Consequently, the early literature describing TPS, e.g. Ashburn (1977), Sugimori *et al.* (1977) and Monden (1981d,a,c,b), focused on the most easily identified, tangible elements of the system such as JIT and *kanban*, rather than the system in its entirety. Secondly, lean was often confused with other similar approaches to production management coming out of Japan around the same time, notably Total Quality Management (TQM) as developed by Motorola - a concept with many aspects similar to TPS/lean concerning quality assurance and continuous improvement, but with no emphasis on the JIT part of lean. Thirdly, over the past 30 years since the first literature was published on the Toyota Production System, both TPS and lean have continued to evolve. Toyota has built on and refined its system, and the literature has become much better at grasping and describing the entirety of the system, including its human, organizational and managerial components.

Despite the ambiguity, or perhaps because of it, a range of authors have offered different definitions of lean production. Krafcik (1988) invented the term lean production to describe the Toyota Production System. Indeed, it is commonly accepted that lean production as a concept is based on the practices of TPS (Holweg, 2007). Thus, lean can be seen as being the same as TPS - at least originally. Therefore, definitions of TPS and lean are seen as definitions of the same construct. A selection of definitions of TPS and lean are given in table 2.1 on the facing page.

Source	Definition
Definitions of TPS	
Monden (1983)	The basic idea of TPS is to produce the kind of units needed, at the time needed and in the quantities needed such that unnecessary intermediate and finished product inventories can be eliminated. Three sub-goals to achieve the primary goal of cost reduction (waste elimination) are quantity control, quality assurance, and respect for humanity. These are achieved through four main concepts: JIT, autonomation, flexible workforce, and capitalizing on worker suggestions and 8 additional systems.
Ohno (1988)	The basis of TPS is the absolute elimination of waste. The two pillars needed to support TPS are JIT and autonomation. (...) TPS can be described as an effort to make goods as much as possible in a continuous flow.
Shingo (1989)	The Toyota Production System is 80 percent waste elimination, 15 percent production system and only 5 percent *kanban*.
Liker (2004)	The Toyota Way can be briefly summarized through the two pillars that support it: "Continuous Improvement" and "Respect for People".
Definitions of Lean	
Womack and Jones (1996)	Lean thinking can be summarized in five principles: precisely specify *value* by specific product, identify the *value stream* for each product, make value *flow* without interruptions, let the customer *pull* value from the producer, and pursue *perfection.*
Shah and Ward (2007)	Lean production is an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability.
Scherrer-Rathje *et al.* (2009)	Lean is a management philosophy focused on identifying and eliminating waste throughout a product's entire value stream, extending not only within the organization but also along the company's supply chain network.
Liker and Rother (2011)	The focus of lean is on the customer and the value stream. You can say it is a pursuit of perfection by constantly eliminating waste through problem solving.

Table 2.1: Definitions of TPS and lean.

Evidently, there are many definitions of TPS and lean. They each highlight different elements of the system. For the purposes of this research, the following definition of lean is offered, which the author argues incorporates the essential elements:

> *Lean is an integrated socio-technical system which seeks to increase value and decrease costs by removing waste and continuously improving the business through a culture of problem solving and a set of mutually reinforcing operational and managerial tools and practices.*

2.2.2 Elements

Lean is a complex system with a multitude of different elements. Several authors have attempted through surveys, literature reviews etc. to construct a comprehensive lists of the elements of lean production, yet with each new list there are differences from the previous (Im and Lee, 1989; McLachlin, 1997; Åhlström, 1998; Shah and Ward, 2003; Bhasin and Burcher, 2006). Attempts have also been made by scholars such as Shah and Ward (2007) to consolidate the operational elements of lean into a smaller selection of higher-level aggregate constructs that are more measurable, yet this approach sacrifices detail and richness of complexity in favor of measurability. As such, there is no 'end-all be-all' list of elements of lean production. Therefore, this review of the elements of lean production offers the 'Toyota House of Production' (henceforth the Toyota House) as depicted by Liker (2004) as a starting point for describing the system. The Toyota House can be seen in figure 2.1. This review of the elements of lean production will proceed in this order: first, the

Figure 2.1: The Toyota House of Production by Liker (2004).

very bottom level of the foundation of the Toyota House - the Toyota Way philosophy and culture - is discussed. Next, the remainder of the foundation - leveled production, stable and standardized processes, and visual management - are discussed under the heading of 'operational stability'. From this the review proceeds to describe the two 'technical tools' pillars of *jidoka* and JIT. Then, the middle pillar which consists of continuous improvement through waste reduction as well as people and teamwork is discussed. Finally, there are some alleged elements of lean that are not incorporated in the Toyota House. These are discussed last.

Philosophy and Culture

While it has been a common misconception that lean is a pick-and-choose toolbox (Hines *et al.*, 2004), the evidence that it is much more than that has been there from the very start. Both Monden (1983) and Shingo (1989) emphasize that the Toyota Production System is, in fact, a *system* - Shingo even talks of explaining the *philosophy* behind the system. Shingo (1989) states:

> *"Most of the existing publications are filled with flowery descriptions of the Toyota production system and Toyota's 'kanban method.' Yet, no effort is made to reveal the true essence of the system. (...) As long as the Toyota production system is seen as merely a production control system, it will not differ in essence from other production control systems. However, the Toyota production system is an extrapolation of an idea I have stressed in my seminarss, a way of thinking about production management in terms of a fundamentals-oriented view of plant improvement."*

As such, Shingo explains that TPS is a philosophy towards plant improvement. He further explains that if one does not possess an adequate understanding of the principles behind the system: *"(...) you are likely to make serious mistakes which will result in the failure of the system - even if you have a clear understanding of individual techniques."* Ohno (1988) further suggests that TPS is more than just a production system, but an overall management system:

> *"The Toyota production system, however, is not just a production system. I am confident it will reveal its strength as a management system adapted to today's era of global markets (...)."*

Convis (2001) states that: *"TPS is an interlocking set of three underlying elements: the philosophical underpinnings, the managerial culture and the technical tools."* The proponents of this philosophical stance are many. Some refer to it as a system, others as a philosophy or a perspective, and yet again others as a lean *culture* (Liker, 2004; Ballé, 2005; Jørgensen *et al.*, 2007; Atkinson, 2010). So many authors have tried to concretize the essence of this lean philosophy in a set of 'guiding principles' (all of which share some commonality but neither of which are building on each other) to the point that it is more confusing than helpful (Joyce, 2011). Most notable among these are Womack and Jones (1996), Spear and Bowen (1999) and Liker (2004). Womack and Jones (1996) present five principles of lean production: focus on value, identify the value stream, establish flow, establish customer pull, and pursue perfection. Spear and Bowen (1999) describe the DNA of TPS as four 'rules' which can be summarized as: standardization of work, uninterrupted work flows, direct links between suppliers and customers, and continuous improvement based on the scientific method. Finally, Liker (2004) describes the essence of TPS as a set of no less than fourteen principles which, fortunately, he divides into four groups which he names the 4P's: long term *philosophy*, the right *process* will produce the right results, add value to the organization by developing your *people* and partners, and continuously solving root *problems* drives organizational learning.

There are, however, some general themes as to what the essence of the lean philosophy or culture is. Most obvious is the concept of **waste reduction**, which is emphasized by virtually every source on the matter (Monden, 1983; Ohno, 1988; Shingo, 1989; Womack *et al.*, 1990; Womack and Jones, 1996; Allen, 2000; Liker, 2004; Ballé, 2005). The most commonly known type of waste is *muda*, waste in operations and processes (Ohno, 1988). There are at least seven types of *muda*. These are seen in figure 2.2. The basic idea is that these things are unneccessary and inherently wasteful and should be eliminated. While some are obvious (waiting for example), the notion that overproduction and inventory are wasteful challenged conventional wisdom of mass production at the time. The argument of Ohno and Shingo was that overproduction leads to inventory, and that inventory covers up problems inherent in the production system such as machine breakdowns, poor material availability, defects and scrap, etc. While establishing inventory to cover for these problems is convenient, it does not solve the root cause of the problems. Only by removing the inventory and uncovering the problems can the quality of products and the overall performance of the production system be improved (Shingo, 1989).

Figure 2.2: The seven wastes of production (Ohno, 1988).

Two other types of waste that, to Toyota, are equally as important as *muda* are *mura* (inconsistency or unevenness) and *muri* (overburden, unreasonableness or absurdity) (Liker, 2004). The former refers to an irregular production schedule caused by internal inconsistencies (batching, poor scheduling) or external inconsistencies (volatile demand and supply). The latter refers to pushing a machine or employee beyond its/his natural limits and thereby causing safety problems, quality problems, breakdowns and defects (Liker, 2004). Womack (2010) recently expressed his concern that the excessive focus on *muda* by academics and practitioners alike, and the consequent lack of attention paid to *mura* and *muri*, is preventing people from succeeding in actually removing waste.

Equally oft-mentioned are the principles of **continuous improvement** or *kaizen* (Monden, 1983; Ohno, 1988; Shingo, 1989; Womack and Jones, 1996; Spear and Bowen, 1999; Convis, 2001; Liker, 2004; Ballé, 2005; Bhasin and Burcher, 2006; Atkinson, 2010; Liker and Rother, 2011) and **respect for humanity** (Monden, 1983; Ohno, 1988; Krafcik, 1988; Convis, 2001; Liker, 2004), which are the two main elements of Toyota's own internal 'Toyota Way' document of 2001 by then-CEO Fujio Cho (Liker, 2004). According to Liker (2004), the Toyota Way is the foundation of TPS: *"The Toyota Way and the Toyota Production System (...) are the double helix of Toyota's DNA; they define its management style and what is unique about the company."* Continous improvement is the principle of always challenging the existing way of operating and striving for perfection in all aspects of the business. Key elements are *genchi genbutsu* (to go to the source and base decisions on facts), to always seek to find the root cause of a problem, and to use problem solving techniques to implement solutions that prevent reoccurence (Shingo, 1989; Spear and Bowen, 1999; Liker, 2004). Respect for humanity represents the belief that people are the core asset of the company, that they are the key to actually achieving continuous improvement, and that employee safety is always the number one concern (Liker, 2004). Therefore, it is important that the employees are involved in continuous improvement activities, empowered to make decisions and changes, and given the training that is necessary to be able to see the opportunities for improvement as well as implement these (Allen, 2000; Liker, 2004). The concept also emphasizes respect, trust and teamwork (Convis, 2001).

The last major aspect of the lean philosophy is **long-term thinking** (Shingo, 1989; Womack and Jones, 1996; Convis, 2001; Liker, 2004; Bhasin and Burcher, 2006). Shingo (1989) states that while it will not take other companies as long time to copy the system as it took Toyota to develop it, they should still expect it to take about 10 years - and he is only talking about the manufacturing system. Womack and Jones (1996) believe it takes five years to fully implement lean, while several others make the point that lean should not be viewed as a state to be reached as much as a direction, a journey that never ends (Karlsson and Åhlström, 1996; Bhasin and Burcher, 2006). Finally, studies have shown that lean does not stand much chance of success under a short-term profit oriented management (Im and Lee, 1989).

Operational Stability

This category incorporates the elements of stable and standardized processes, visual management, and leveled production or *heijunka*. In some versions of the Toyota House of Production, the entire bottom foundation of the house is called 'operational stability'. While not given much attention as a discrete concept in the early lean literature, operational stability is a key element of the Toyota Production System. Krafcik (1988) hinted at it when he coined the term 'lean' to describe the main difference between TPS and mass production's 'buffered' production system. He describes the buffered production systems:

> *"The production systems of most Western producers (...) were buffered against virtually everything. Inventory levels were high, buffering against unexpected quality problems; assembly lines had built-in buffers to keep production moving if equipment broke down; legions of utility workers were kept on the payroll to buffer unexpected periods of high absenteeism; repair areas were huge to buffer against poor assembly line quality, and so on."*

The key point here is that instability in operations in terms of lack of standardized work, machine breakdowns, lack of manpower etc., were tolerable in mass production environments because there were buffers in the form of e.g. inventory and excess people to absorb the variance. Lean recognizes these buffers as inherently wasteful and seeks to remove them, and this creates a much greater need for operational stability. If the buffers are not there, any instability directly affects the performance of the system. The importance of minimizing variance is recognized by Shah and Ward (2007) in their definition of lean, which emphasizes minimizing supplier, customer and internal variability as the main means of eliminating waste. Yet, with all the hype concerning Just-in-Time techniques and tools, many companies neglect the importance of stabilizing the process (Liker, 2004; Smalley, 2006). Marchwinski (2006) states: *"You can't build a house of production unless you have a strong foundation."* He emphasizes focusing on: *"(...) basic stability concepts such as the five S, visual controls, preventive maintenance, and rigorous problem solving (...)."* A study by Herron and Braident (2007) showed that while most Japanese companies are familiar with the concepts of Just-in-Time and *jidoka*, the basis of lean manufacturing in Japan is a base operating methodology known as *genba kanri*, which involves 5S, developing and training people in standardized work, basic autonomous plant maintenance, SMED and continuous improvement (Herron and Braident, 2007).

The main elements of stable and standardized processes are **standardized work** and **preventive maintenance** (Liker, 2004). Standardized work achieves stability by establishing a best current way of performing the work, and training everyone based on this (Shingo, 1989; Huntzinger, 2006). The standardized work sheet specifies the cycle time, the standard work sequence and how long time each step should take, and the standard inventory that should be at the workstation (Ohno, 1988). To achieve stability in terms of equipment availability, lean relies on preventive maintenance (PM) (Hancock and Zayko, 1998), and in some cases the more advanced concept of Total Productive Maintenance (TPM) (Liker, 2004).

Visual management is mainly materialized in the form of **5S** and **vertical information systems**. Five S or 5S is a workplace organization methodology that creates a visual, orderly workplace where problems and abnormalities are easily identified for correction (Liker, 2004). There are different versions of what the 5S stand for, one of which is: sort (only the necessary things should be at the workplace), straighten (there should be a place for everything and everything should be in its place), shine (keep the workplace clean), standardize (everyone should do the job in the same way using the same tools) and sustain (employing self-discipline to maintain and review the standards). Vertical information systems are systems for making information about the current status of the production visible and easily understandable for everyone at a glance. This is often accomplished by means of information boards on the shop floor (Åhlström, 1998).

Finally, **leveled production** or *heijunka* is the last element of operational stability. Heijunka is the leveling of production by both volume and product mix. While the ideal for TPS and lean in the beginning was to only build to customer order, it was soon realized that while a noble goal, this was practically infeasible as customers do not order in a stable pattern - customers may order a lot on Monday, and nothing on Friday for example. Therefore, rather than build exactly to customer order, lean utilizes *heijunka* to take the total volume of orders in a period and level them out so the same amount and mix are being made each day (Liker, 2004).

It is worth noting that many of the tools and techniques within the category of operational stability are aimed at addressing *mura* (unevenness or inconsistency) and *muri* (overburden) rather than the traditional waste of *muda*.

Jidoka

According to Ohno (1988), *jidoka* is one of the two original pillars of TPS. The word *jidoka* means the separation of worker from machine through pre-automation or autonomation (Shingo, 1989). The reason that workers had to stay at machines in a mass production environment despite the machine doing most of the actual work that the operators had previously been doing was the fact that the machines were incapable of detecting and correcting abnormalities, i.e. defects (Shingo, 1989). Therefore, the method for achieving *jidoka* became to build quality checks into the process itself through methods such as *poka-yoke*, hence the subtext 'built-in quality' in the Toyota House seen in figure 2.1. Since, the *jidoka* pillar has come to represent the 'quality' element of lean production, and therefore now also includes non-automated tools such as the *andon* and the concept of informative inspection (checking every item and reporting back to previous processes whenever a defect is detected), also known as 100% inspection. The primary techniques associated with the *jidoka* pillar are described in table 2.2. It is important to mention that a key concept of *jidoka* is to **stop the line** whenever a problem occurs. Indeed, that is very much the purpose of both *poka-yoke* and *andon* - in the case of the former, to stop the line automatically if something goes wrong, and in the case of the latter, for the operator to be able to stop the line when he detects an abnormality and immediately signal the need for support (Shingo, 1989). This dedication to stop the line when problems occur is part of the problem solving mindset previously explained - stopping the whole line when a problem occurs creates a sense of urgency for everyone to help solve the root cause of the problem as fast as possible (Liker, 2004). Thus, *jidoka* serves two purposes: ensuring quality and zero defects, and highlighting issues for problem solving. In fact, it serves a third purpose: like the techniques to ensure operational stability, *jidoka* also plays an important role in making a Just-in-Time system work, as is described in the next section.

Technique	Description
100% inspection	Inspection of every unit produced at every step of the process through either self-inspection or successive inspection (inspection is done at the next step in the process) (Shingo, 1989).
Poka-yoke (error-proofing)	*Poka-yoke* is a mechanism to prevent defective work by putting various checking devices on the implements and instruments (Hancock and Zayko, 1998).
Andon	The *andon* is a visual control that communicates important information and signals the need for immediate action by supervisors (Shingo, 1988). *Andon* is a visual management tool that highlights the status of operations in an area at a single glance and that signals whenever an abnormality occurs (Marchwinski, 2006).

Table 2.2: The techniques belonging to the *jidoka* pillar.

Just-in-Time

Emphasized by Ohno (1988) as one of the two pillars of TPS, just-in-time (JIT) is without a doubt the most publicized element of lean (Liker, 2004). According to Ohno (1988): *Just-in-time means that, in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and only in the amount needed."* The elements of the JIT pillar are those that are most commonly associated with lean production: takt time and value stream mapping, one-piece flow, cell layout, rapid changeovers using the SMED (Single-Minute Exchange of Die) technique, and pull scheduling using *kanban* being the most prominent. A short description of each of these techniques is given in table 2.3. All of these are commonly accepted elements of lean production, and fairly well known (Shah and Ward, 2007). Rather than discuss the relevance of these techniques, it would be prudent to discuss exactly how these techniques integrate with each other and the techniques of *jidoka* and operational stability to accomplish just-in-time production.

Technique	Description
Takt time	Tact is the time it takes to produce one piece of product. This time is equivalent to total working time divided by production quantity (Shingo, 1989). Takt time is the rate of customer demand – the rate at which the customer is buying a product (Liker, 2004).
Value stream mapping (VSM)	Value stream mapping is a pencil and paper tool that helps you to see and understand the flow of material and information as a product makes its way through the value stream (Rother and Shook, 1998).
Cell layout	The arrangement of machines and equipment based on the sequence of the manufacturing process (Ohno, 1988).
SMED	A technique for reducing the amount of time it takes for a machine or a production line to change from producing one product to another (Shingo, 1989).
Pull	A principle for production control where production of materials at the upstream process is only initiated upon request from the downstream process (the customer) (Nicholas, 1998).
Kanban	The *kanban* system is an information system which harmoniously controls the production quantities in every process (Monden, 1983). *Kanban* is a system that uses a card to signal a need to produce or transport a container of raw materials or partially finished goods to the next stage in the manufacturing process (Nicholas, 1998). The *kanban* system manages the JIT production method (Monden, 1983).
Line balancing	An approach to the loading of work on operators on a line where the amount of work is divided evenly between the operators consuming almost the entire takt time interval (Rother and Harris, 2001).
One-piece flow / continuous flow	In a one-piece flow, each transportation lot is equivalent to one piece (Shingo, 1983). Continuous flow refers to producing one piece at a time, with each item passed immediately from one process step to the next (Rother and Shook, 1998).

Table 2.3: The techniques belonging to the Just-in-Time pillar.

In the ideal JIT system, products are only produced to actual customer orders (pure **pull**), in a **one-piece-flow**. That way there will be no finished goods inventory and no work-in-process inventory. However, producing to actual customer orders is often infeasible as the total lead time of a product is often longer than the demand lead time from the customer (Shingo, 1989), and because customers do not order in a stable pattern (Liker, 2004).

Therefore, to faciliate one-piece flow, lean utilizes ***heijunka*** to level the production volume and mix (Liker, 2004). Leveling the production mix requires smaller lot sizes, which in turn requires faster changeovers, for which the **SMED** technique is used to drastically reduce set-up times (Shingo, 1989). A level volume facilitates determining a **takt time**, which represents how often, on average, a product must be produced (Rother and Shook, 1998). Establishing takt time enables **line balancing**, a precondition for one-piece-flow. Line balancing entails spreading the work of producing the product evenly amongst operators, with the work amount of each operator as close as possible to the takt time, to minize waste. Furthermore, the physical arrangement of work stations and machines in a process or **cell layout** is necessary for materials to flow directly from one work station to the next, one piece at a time (Rother and Harris, 2001). Due to line balancing and *jidoka*, the separation of worker from machine, a single operator might find himself operating multiple machines or work stations within the same product cycle, thus the need for **multiskilling** (Ohno, 1988). Where one-piece-flow is not possible, the ***kanban*** system is utilized, although this requires tolerating some work-in-process inventory in the form of *kanban* containers (Rother and Shook, 1998). Furthermore, whether one-piece-flow or *kanban* is utilized, since the goal is to eliminate waste and thus minimize the amount of inventory, variance must be eliminated and stability promoted. Variance in demand or supply ruins the one-piece-flow effort as the basic premise is that each operator spends an equal amount of time on each piece. If one operator on an assembly line works too fast, it creates supply variance for the next operator, and demand variance for the previous operator. Similarly, variance ruins the *kanban* system as larger variance necessitates increasingly large safety stocks between work stations to absorb this variance, and consequently, more *kanban* containers and more inventory, which is waste (Nicholas, 1998; Herron and Braident, 2007). Leveling the production by means of *heijunka* effectively minimizes the variance in demand as it levels both the volume per day, and levels the mix of different variants as evenly as possible over the course of the day. In order to minimize the variance in supply, **stable and stardized processes** as well as **zero defects** is necessary (Nicholas, 1998). Stable and standardized processes are achieved through **TPM** (total productive maintenance) which reduces the variance in supply due to machine breakdowns, and **standardized work**, which reduces the variance in supply and demand that would result from one operator doing the work differently from the other (and consequently being either slower or faster, both of which create variance). Additionally, the emphasis on people empowerment, involvement and motivation is part of Toyota's strategy for how to minimize the variance in manpower, and JIT-delivery from suppliers is the method used to eliminate the variance in supply of materials while simultaneously keeping raw material stock to a minimum (Liker, 2004). Both of these concepts are touched upon in the following sections. Defects also create variance in the system, as defective products at one stage in the process will produce demand variance for all the upstream processes which will have to produce new parts, and supply variance for all the downstream processes which will experience a material shortage. Therefore, achieving zero defects through ***jidoka*** and its techniques of ***andon***, ***poka-yoke*** and **100% inspection** is necessary to make JIT work (Monden, 1983; Shingo, 1989).

Continuous Improvement

Continouous Improvement or *kaizen* is part of the middle pillar in the Toyota House. Most of the early sources - Monden (1983), Ohno (1988) and Shingo (1989) - emphasize continuous improvement through root cause analysis and subsequent problem solving as an important element of the system. Shingo (1989) states that Toyota's approach is to discover and implement solutions that permanently prevent a problem from reoccuring. This is done through the use of root cause analysis problem solving techniques such as 'Five Why' (asking 'why?' five times to get to the root cause of a problem rather than the more obvious symptoms of it) whenever a problem occurs. Ohno even states that the Toyota Production System was built on the practice and evolution of this scientific approach (Ohno, 1988). These same points are made by Womack and Jones (1996), who further argue that companies that wish to become lean must make the focus of daily operations about eliminating the root causes of problems rather than traditional 'firefighting'. An important concept to facilitate this problem solving is that of *genchi genbutso*, to 'go and see' the actual condition for yourself in order to thoroughly understand it (Liker, 2004). Spear and Bowen (1999) emphasize that Toyota employees have a common vision of what the ideal is, and utilize a rigorous scientific method of problem solving and experimentation to continuously challenge the existing way of doing things. The foundation of this scientific method is the many standardizations that characterize processes and work within Toyota, which specify the current best way of doing a specific job. These essentially serve as a set of hypotheses that can be challenged and tested (Spear and Bowen, 1999). The obvious example of this is the standardized work sheet which states the current best way of performing a task. If the operator cannot perform the job within the required time then there is a problem either with the operator who must receive additional training, or in the assumptions behind the standardized work sheet. Either way, the standardized work sheet becomes a tool for problem solving (Shingo, 1989). Conversely, the standardized work sheet also represents the kind of hypotheses that Spear and Bowen (1999) refer to, which must be challenged regularly in order to improve the process. Indeed, Shingo (1989) states that at Toyota, people are encouraged to feel ashamed if a standard work sheet remains unchanged for longer periods of time. The points made by Shingo (1989) and Spear and Bowen (1999) are reinforced by Liker and Rother (2011), who assert that:

> *"The reality is that very little that you see at a Toyota site is the result of one person with a big idea that got standardized across plants. More often, what you see is today's condition, which is the result of many small steps, some of which were discarded and others embraced. It was the result of many cycles of plan-do-check-act (PDCA) (...)."*

They further argue that developing an 'improvement *kata*' - a routine and capability for continously challenging the existing and finding ways to solve the problems that occur on the way to meeting the new goal - is the key aspect to becoming a lean company (Liker and Rother, 2011). They are backed up in this by Jørgensen *et al.* (2007) who state that developing such capabilities contributes to the creation of a learning organization. Liker and Rother (2011) further explain that the technical lean tools such as *kanban*, apart from controlling the production flow, serve much the same purpose as the standardized work sheet: it establishes a target condition, which the people in the system must are challenged to meet. Thereby it generates a behavior of problem solving your way through the obstacles to achieve the target condition (Liker and Rother, 2011).

People

The second part of the middle pillar of the Toyota House is people & teamwork. Convis (2001) asserts that people and the development of human resources is at the very core of TPS. He argues that while the tools are important: *"(...) the basic tenet of TPS is that people are the most important asset (...)"*. This same point is put forth by Liker (2004) who explains that the Toyota Production System is a system designed to provide the tools for the employees to continuously improve the business, and consequently, it relies on people to infuse it with energy and bring it to life. Allen (2000) emphasizes that the workers are often the most knowledgeable about their specific parts of the manufacturing process, and therefore, in a lean production system, the employees should be both involved in the lean effort and empowered to make decisions about improvement in their daily work. Ballé (2005) concurs and argues that real lean leaders know that their role is not to solve the problems, but to involve the employees in solving them. Because employees are the core asset of the system, the role of managers in a lean system is different from traditional mass production in that a manager's role in a lean system is actually to support the employees rather than manage them (Convis, 2001; Åhlström, 1998). As Gary Convis, the first American to become president of a Toyota plant as he headed Toyota Motor Manufacturing Kentucky, reminisces about a piece of advice given to him by former president of NUMMI (New United Motor Manufacturing, Inc., a North American Toyota-General Motors joint venture), Kan Higashi:

> *"When he promoted me to vice president, he said my greatest challenge would be 'to lead the organization as if I had no power.' In other words, shape the organization not through the power of will or dictate, but rather through example, through coaching and through understanding and helping others to achieve their goals. This, I truly believe, is the role of management in a healthy, thriving, work environment."*

Lean production also approaches work organization from a different angle than traditional mass production. Ohno (1988) emphasizes the importance of teamwork in TPS by exemplifying how one employee performing exceedingly 'well' will only cause overproduction - the team must work together to ensure the maximum performance of the process rather than the individual operators. The system also relies on teams for the continuous improvement effort (Krafcik, 1988). The importance of teams as a supporting structure in a lean production system is also emphasized by Tracey and Flinchbaugh (2006). Krafcik (1988) also notes that the role of the team leader is a significant feature of TPS, with the team leader not having a direct responsibility on the line but rather being responsible for tasks traditionally performed by support functions such as training of team members, faciliating continuous improvement and problem solving, preventive maintenance, quality inspection etc. Lastly, employee training and especially the concept of multi-skilling is a necessity for lean to function, as the system relies on operators being capable of operating several different machines and performing a variety of tasks (Ohno, 1988). Piatkowski (2004) explains that Toyota employees are given a five-day introduction to TPS, including both technical and organizational elements. Jørgensen *et al.* (2007) argue that for companies that are not yet where Toyota are at, investing in such employee training is even more important to develop the kind of capability for problem solving, learning, continuous improvement and application of lean techniques that Toyota has. For the remaining training, TPS relies on on-the-job-training performed by the organization's managers themselves, and learning by doing. The managers act as coaches and mentors of those below them, all the way down to the team leaders, who are taught to instruct new operators in how to do their work (Piatkowski, 2004).

Additional Elements

There are some elements which are mentioned in the literature as being part of lean, but which are not directly represented in the Toyota House. These are discussed here. Firstly, many authors advocate the use of supplier partnerships. Monden (1983) explains that the *kanban* system should be extended into the supplier base to allow for Just-in-Time delivery of raw materials, and thereby the ability to reduce raw materials stock for the company, and finished goods stock for the supplier. Liker (2004) argues that this is best accomplish by developing the supplier rather than bullying it, and explains how Toyota has established a Toyota Supplier Support Centre to aid its suppliers in becoming lean. Womack and Jones (1996) regard the extension of lean into the supply chain as a natural step in the implementation of lean in a company, which is supported by Stamm (2003) who argues that every company will reach a point in its lean effort where it realizes that to continue improving, it must integrate the whole supply chain in the lean program.

Secondly, there is the topic of the supporting systems such as the performance measurement system, the management accounting system, and the reward system. Womack and Jones (1996) contend that to ensure that the lean effort has the company's best interests at heart, policy deployment or *hoshin kanri* must be utilized to formulate performance measures in a way that ensures that activities at all levels of the organization are aligned with the company's strategic objectives, and thus ensure that resources are used in a way that helps the company achieve its goals. This is also reported by Liker (2004) who argues that Toyota measures the same things as everyone else e.g. productivity and quality, but that there are some things that characterize their measurement system which makes it different from most others: they use only a few, solid performance measures, they set extremely concrete targets and do not accept vague targets or measures, and a plan is developed on each level of the organization down to work group level for how they are going to achieve their targets. Perhaps most importantly, Toyota managers are process oriented rather than result oriented; instead of demanding immediate bottom line results, they are patient and believe in the continuous improvement process and their people to provide the results in due time (Liker, 2004). While this method works for Toyota, several authors argue that traditional performance measurement methods are not suitable for lean production and that new ideas are required (Toni and Tonchia, 1996; Bhasin, 2008; Fullerton and Wempe, 2009). The same is the case for the accounting system, as studies have shown that traditional accounting practices have a negative effect on the success of lean production (Karlsson and Åhlström, 1996). Some authors argue in favor of activity based costing (Womack and Jones, 1996), while yet again others argue that an entirely new way of doing accounting which supports lean must be utilized (Maskell, 2000). Finally, companies must consider to change their reward system to one that more adequately promotes lean objectives rather than, for example, piece-rate based traditional reward systems which basically encourage overproduction (Karlsson and Åhlström, 1995).

Finally, there is the concept of *kaikaku* which means 'radical change', often referred to as '*kaizen* events', 'blitz *kaizen*' or '*kaizen* workshops', as a vehicle for the implementation of lean. These are events where, for a short period of time, a large amount of resources in terms of a cross-functional team of people that are usually tied up elsewhere in the organization are dedicated to work on a specific process, to be able to rapidly implement a series of changes and iterate upon these to create radical change that would otherwise take months to achieve (Liker, 2004). This approach is advocated by both Womack and Jones (1996) and Liker (2004) as an important tool to create momentum and implement larger changes in a process. However, Liker (2004) cautions that companies must not come to rely on these kind of events as the sole source of lean changes and improvements in the organization - continuous improvement must be the main source of that.

2.2.3 Benefits

The work of the IMVP showed that lean plants tend to perform better than other plants that do not use lean manufacturing methods and management policies, with 'leanness' being an extremely good predictor of plant performance in their benchmarking study of the automotive industry (Krafcik, 1988). The lean plants were able to achieve higher levels of both productivity and quality, thus eliminating what was believed to be one of the traditional manufacturing tradeoffs. Womack *et al.* (1990) assert that lean production:

> *"Uses less of everything (...) half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time (...). Also, it requires keeping far less than half the inventory on site, results in many fewer defects and produces a greater and ever growing variety of products."*

Womack and Jones (1996) further contends that lean doubles labor productivity, reduces lead times by 90%, reduces inventories by 90%, and reduces both quality defects and job related injuries by 50%. Mackelprang and Nair (2010) recently confirmed that lean leads to increased performance in an empirical study that showed a positive association between lean and aggregate performance - a construct comprised of quality, cost, inventory, cycle time, flexibility and delivery performance. That lean production improves performance on these traditional parameters is echoed by many. An overview of the various tangible and intangible benefits of lean production is given in table 2.4.

Benefits of lean production	Im and Lee (1989)	Womack et al. (1990)	Sohal and Egglestone (1994)	Womack and Jones (1996)	McLachlin (1997)
Tangible benefits					
Increased quality	X	X	X	X	X
Increased productivity	X	X	X	X	X
Reduced costs	X	X		X	X
Reduced inventory	X	X		X	X
Reduced lead time	X	X		X	X
Reduced cycle time			X		
Space savings		X			X
Reduced job injuries				X	
Intangible benefits					
Increased flexibility	X	X	X		X
Better work environment	X	X			X
Better market position			X		
Better customer relationships			X		
Better supplier relationships			X		
Better problem solving capabilities	X				X
Better communication	X				

Table 2.4: The tangible and intangible benefits of lean production.

2.2.4 Limitations and Criticism

Like every major concept, lean production has its critics. Using the phrase "lean and mean", Allen (1997) argues that lean initiatives often take the shape of downsizings and restructurings, with two major consequences: layoffs, and an atmosphere of insecurity and mistrust within the remaining workforce due to subpar communication from management about the ongoing changes. This is backed up by Philips (2002) who suggests that layoffs lead to reduced employee support for lean activities. Summarizing the findings of other authors, Jørgensen *et al.* (2007) state that the increased intensity and higher degree of standardization of the work content can have a negative impact on the physical and psychological health of the employees. Jørgensen *et al.* (2007) further speculate that these negative effects on the workforce may be caused in part by a skewed focus on the implementation of lean tools and techniques as opposed to a lean culture and social environment, a sentiment that is backed up by Hines *et al.* (2004).

In their review of lean thinking, Hines *et al.* (2004) critize lean on several points in addition to the human aspect mentioned above. Firstly, they argue that lean has a problem with coping with variability. As indicated by the definition given of lean by Shah and Ward (2007) in section 2.2.1, reducing variability is indeed a chief objective of lean production. However, Hines *et al.* (2004) argue that while some of the lean tools for ensuriing operational stability and leveling the production are aimed at addressing this very issue, lean still tends to perform poorly in businesses with high variability, where alternative concepts such as 'agile' manufacturing are better suited.

Related to this is the discussion of contingency - the notion that lean will only work properly in major industries with stable demand such as the automotive industry in which it was invented. The critics on this point base their arguments on the contingency school of organizational design (Child, 1977). According to Hines *et al.* (2004) and Allen (2000) this was a popular excuse for not adoptiong - or failing to adopt - lean in the early years after the 'Machine' book. While certainly there are industries in which other methodologies will be more effective, the notion that lean only works in the automotive industry has since been proved wrong by the successful adoption of lean in a range of other industries (Allen, 2000).

Some authors also argue that an overzealous focus on lean production and in turn waste elimination, cost reduction and operational excellence, can have a negative impact on the future competitiveness of the company. Ross and Francis (2003) argue that while lean has its merits, it is not enough to sustain the business in the long term, since it does not focus sufficiently on innovation. This notion was tested empirically by Lewis (2010), whose studies suggested a correlation between the advancement of lean production in two companies, and a corresponding decrease in their focus on innovation. This is related to the notion of core capabilities becoming 'core rigidities' (Leonard-Barton, 1992), but it is arguably a much more fundamental strategic discussion about balancing the efforts of efficiency in current operations (exploitation) with innovation (exploration), which is not limited to lean production as a concept (March, 1991).

2.3 Change Management

According to Todnem (2005), the successful management of change is a necessity to succeed in today's highly competitive and continuously evolving global environment. Hiatt and Creasey (2011) define change management as:

> *"Change management is the process, tools and techniques to manage the people-side of business change to achieve the required business outcome, and to realize that business change effectively within the social infrastructure of the workplace."*

Traditionally, there have been two different perspectives on change management: planned change and emergent change (Bamford and Forrester, 2003). Planned change is based primarily on the metaphor of the organization as a 'machine', which assumes that organizations can be changed by those in positions of authority as long as resistance is managed and the process is well planned, controlled and executed (Cameron and Green, 2004). Planned change was pioneered by Lewin (1951) who argued that organizational change is a process of transitioning from one state to another through a series of steps which can be planned in advance by management. This transition can be successful only when the driving forces for the change outweigh the opposing forces. Common for the proponents of the planned change approach such as Bullock and Batten (1985) and Kotter (1995) is the belief that there is a 'one best way' of managing change (Burnes, 1996).

Planned change has been criticized for oversimplifying the complex process of organizational change (Bamford and Forrester, 2003). As an alternative, the concept of 'emergent change' was developed, which sees change as a continuous managerial process in which the organization constantly strives to align itself with its environment, rather than a one-off creation of a battle plan which is then carried out. However, Bamford and Forrester (2003) assert that the proponents of the emergent approach are more united in their critique of planned change than in their agreement on an actual alternative. According to Burnes (1996), the emergent approach: *"(...) stresses the developing and unpredictable nature of change. It views change as a process that unfolds through the interplay of multiple variables (context, political processes and consultation) within an organization (...)."* Bamford and Forrester (2003) have tried to put the discussion about planned versus emergent change to bed by drawing on contingency theory and arguing that there is no one best way to change - both are useful under different circumstances.

Regardless of approach to change, there are a set of commonly agreed upon 'change drivers' which both help drive the necessity for change, and drive the process of implementing the change. According to Whelan-Berry and Somerville (2010), change drivers can be defined as:

> *"Events, activities or behaviors that facilitate the implementation of change."*

In their review of change management literature, Whelan-Berry and Somerville (2010) identified eight commonly agreed upon change drivers:

- Accepted vision
- Leaders' actions
- Communcation
- Training
- Employee participation

- Aligned human resource practices
- Aligned organization structure and control processes

Establishing a 'change vision' for what the purpose and direction of the change initiative is is imperative, but it is not enough to simply establish it - all relevant stakeholders must also buy-in to the vision and accept it. Top management leadership and support is one of the most well-known change drivers, but recent research has discovered that simply providing support in name only is not enough; leaders must actively support the change initiative through their behavior and participation in implementation activities. Communication is important in order to secure employee understanding and motivate change, and in order to keep the organization focused on the change initiative. The communication should be two-way; management should listen to employees too. Training is also necessary, both to enhance the employees' understanding of the change initiative, but also to develop practices and behaviors that embody the change vision; in this way, training provides *meaning* to the vision so that employees can better relate to what the vision means for their daily life. Employee participation and involvement in the planning, design and implementation of changes deepens their knowledge and understanding, provides a sense of ownership, and thereby increases commitment to the change. Human resource practices such as training, hiring, performance measurement and rewards, promotion etc., must also be aligned with the change, to root the changes in the social system of the organization. Finally, the organizational structure as well as control processes such as planning, budgeting, reporting and technology systems may also need to change to be aligned with the change initiative. This includes systems for monitoring, measuring and managing the change initiative itself, which has been identified as critical to change success as it sends the important message to employees that this change initiative is important (Whelan-Berry and Somerville, 2010).

2.3.1 Lean from a Change Management Perspective

Nordin *et al.* (2008) assert that because implementing lean is not only a technical issue but also requires organizational and cultural change, effective change management is as critical to lean as it is to any other change initiative. Naturally, the literature on lean from a change management perspective is not much different from the general change management literature, as the same main topics are highlighted.

Strategic Plan and Dynamic Process

The debate between planned versus emergent change is present in the lean change management literature as well. Stamm (2003) asserts that planning is a basic necessity for lean implementation, and that venturing forth without a roadmap will only result in disappointment as the initiative fails to materialize into more that sporadic quick fixes. This is supported by Bhasin and Burcher (2006) as well as Herron and Braident (2007), who attest that an essential prerequisite is to align the methodology and tools adoped to implement lean with the organisation's strategic needs. Stamm (2003) further argues that the plan for implementation must be strategically sound and consider the entire organization, not just the manufacturing system. However, he also states that the plan must naturally be subject to change as the process comes along and conditions change, but that: *"(...) it is far easier to modify a plan than it is to create one in the middle of a failing transition."* Worley and Doolen (2006) also contend that implementing lean is a dynamic process, unique to each organization. Allen (2000) concurs and emphasizes that every implementation of lean is unique, and that companies that stop to thorougly think every decision through will benefit. This is supported by Scherrer-Rathje *et al.* (2009) who state that continuous evaluation and adjustment throughout the lean effort is critical.

Vision and Burning Platform

The need for a clear vision in a lean transformation is highlighted by Hines *et al.* (1998), who contend that a very clear vision showing people what the organisation will look like once the transformation to lean is complete is important. This is supported by Stamm (2003) who states that one of the important jobs of top management in a lean transformation is to set the mission and vision for the lean program. Related to this, Liker (2004) argues that management should seek to establish a burning platform or a crisis to create momentum.

Management Support and Active Leadership

Several authors have found that top management support/commitment is a critical factor in lean implementation (Im and Lee, 1989; Sohal, 1996; McLachlin, 1997; Stamm, 2003; Worley and Doolen, 2006). Sohal and Egglestone (1994) argue that changes towards lean must come from the top of the organization and that management must participate actively in the implementation and act as leaders, driving the change process rather than sitting back and waiting for results. The point about active leadership is made by several authors. Scherrer-Rathje *et al.* (2009) found that lean will not succeed without *visible* management commitment. Similarly, Boyer (1996) showed that commitment to lean in name only is not enough. Philips (2002) argues that management stating its support is not enough - it must 'walk the talk' and follow through with actions such as authorizing the necessary investments. Marchwinski (2006) supports this and states that when management does not follow through on change initiatives on the shop floor, they lose credibility fast. A study by Worley and Doolen (2006) also showed that management actively participating in implementation activities on the shop floor helped the lean effort. Conversely, Philips (2002) asserts that many lean programs fail because top management loses interest and focus, and this rubs off on the employees. Worley and Doolen (2006) also found that management can have a negative impact on the implementation process if they do not require people to participate in the lean initiative. The importance of this is supported by Liker (2004), who emphasizes that management must make lean mandatory. An important role of top management is also to deal with barriers to change along the way. Hancock and Zayko (1998) emphasize that top management must not hesitate to remove employees who either can or will not perform in accordance with the lean principles and practices. Bidanda *et al.* (2005) showed that it is necessary to continuously keep tabs on whether conflicts regarding the lean implementation arise, and be prepared to deal with these. The role of management in a lean organization is adequately summed up by Convis (2001):

> *"Management has no more critical role than motivating and engaging large numbers of people to work together toward a common goal. Defining and explaining what that goal is, sharing a path to achieving it, motivating people to take the journey with you, and assisting them by removing obstacles - these are management's reason for being.*

Capable Change Agent

The need for a change agent to drive the change process is also present in a lean transformation. Bhasin and Burcher (2006) emphasize the need to assign a dedicated change champion, and Sohal (1996) argues that having a capable 'champion' or change agent who can drive the change initiatives and keep momentum going is essential. Atkinson (2010) argues that managing the many stakeholders that are involved in a complete organizational lean transformation is one of the main challenges for the change agent. Carreras *et al.* (2009) found that such lean leaders must have a number of character traits, most importantly intelligence, professional brilliance, confidence and ability to withstand resistance, teamleader knowledge, communication skills and charisma.

Communication

Several sources point to the importance of proper communication when implementing lean (Sohal and Egglestone, 1994; Sohal, 1996; Bidanda *et al.*, 2005). Scherrer-Rathje *et al.* (2009) emphasize that management must openly disclose mid- and long-term goals, and that lean 'wins' and successes should be communicated throughout the process. Tracey and Flinchbaugh (2006) support the need for communication during the transformation, especially across organizational boundaries. This is also highlighted by Hancock and Zayko (1998), who argue that cross-shift communication is necessary if the changes are to take root - if focus is only on the day shift, it will be one step forward and two steps back every day. Sohal (1996) points out that effective communication is an important tool for avoiding conflicts and barriers to change by nipping looming problems in the bud. Allen (1997) argues that a clear communication plan is extremely important when implementing lean, especially in cases where layoffs may be an outcome of implementing lean, to avoid animosity towards the lean program and an atmosphere of anxiety and stress amongst the 'survivors' of the change.

Employee Involvement

McLachlin (1997) as well as Im and Lee (1989) and Sohal (1996) found that employee participation as well as promotion of employee responsibility plays a central role in lean implementations. Philips (2002) argues that nothing can be achieved without the support of the shop floor operators. Additionally, Scherrer-Rathje *et al.* (2009) argue that the company should develop mechanisms to encourage autonomy and participation.

Lean Knowledge and Training

There is widespread acknowledgement for the importance of training/education in the implementation of lean (Im and Lee, 1989; McLachlin, 1997; Philips, 2002; Pullin, 2002; Bidanda *et al.*, 2005). Convis (2001) is emphatic that to ensure commitment at all levels of the organization, everyone must be aware of the fundamentals of lean. Stamm (2003) supports and says that you cannot expect your team of change agents to succeed if the participants in the process do not understand the basics. Worley and Doolen (2006) found that the inability of top management to provide the training and education needed to provide employees at all levels with adequate lean knowledge was an inhbitor to the lean implementation process. Hancock and Zayko (1998) argue that *all* levels must receive training; even top management. Additionally, Boyer (1996) highlights that organizations that implement lean should focus on the substance rather than the form of their organizational assets. He argues that instead of focusing on what tools to implement, management should focus on developing the skills and capabilities of their employees so that improvement programs may succeed - a point also made by Jørgensen *et al.* (2007).

Alignment of Culture, Organization and Supporting Systems

Finally, there are a multitude of sources that advocate the need to align the organization and its systems with lean in order to succeed with the change initiative. Stamm (2004) contends that often, companies fail because they try to be *"kinda, sorta lean."* They make relatively comfortable changes, without committing entirely to changing not only the shop floor practices but the entire organization, and struggle as a result because lean and a traditional mass manufacturing environment are not compatible. Convis (2001) asserts that a common obstacle to successful lean implementation is the failure of management to understand that lean is a comprehensive manufacturing *and* management system, and consequently, that it is not just a matter of deploying a set of tools and techniques, but that the management structure and style must change as well. Stamm (2004) supports this and states that a common problem is that the management hierarchy above the shop floor as well as the organization structure of support functions is often not included in the analysis of what must be changed to become lean. Stamm (2004) asserts: *"Their programs are top-down driven, but sometimes top management does not want* its *world to change."* Philips (2002) singles out the change to a problem solving lean culture as well as the establishment of a teamwork environment as the biggest hurdles to lean implementation, and Convis (2001) further contends that managers at all levels must support and participate in the problem solving effort. Convis (2001) also emphasizes that managements role in a lean environment must be to provide support - not to direct. This is supported by Olexa (2002) who explains that one of the major changes that must occur is that middle managers must learn to become facilitators and teachers rather than autocrats.

Concerning the organization structure, Liker (2004) suggests to reorganize the organization around its value streams, and thus break out of the traditional functional silo structure. Tracey and Flinchbaugh (2006) found the development of teams as an important supporting structure for lean implementation. This is supported by Bidanda *et al.* (2005) as well as Åhlström and Karlsson (2000), who assert that a delayering of the organizations to a flatter, team-based hierarchy is important for a successful lean implementation. Liker (2004) also advocates that performance metrics must be aligned with the suggested organizational reorientation towards value streams. This is supported by Tracey and Flinchbaugh (2006) who assert that the organization's measurement procedures must be redesigned to provide ownership of metrics to the shop floor teams and processes. This need for changes to the supporting systems is also brought forth by Karlsson and Åhlström (1995) and Åhlström and Karlsson (1996), who found that not aligning the reward and accounting system to a lean organization will hamper the implementation process.

2.4 Existing Lean Implementation Frameworks

In order to comprehensively review the existing frameworks for lean implementation provided in the literature, each framework is reviewed one by one in chronological order. The frameworks take very different perspectives on the implementation process, with some focusing on the change management aspect while others focus on the technical and/or organizational aspects.

2.4.1 Shingo (1981) - Plan for Introducing TPS

The first piece of structured advice for implementing lean (or in this case, TPS) came from one of the two inventors of the system, Shigeo Shingo. Shingo (1989) presents a draft plan for implementing TPS in a hypothetical plant, which can be seen in figure 2.3.

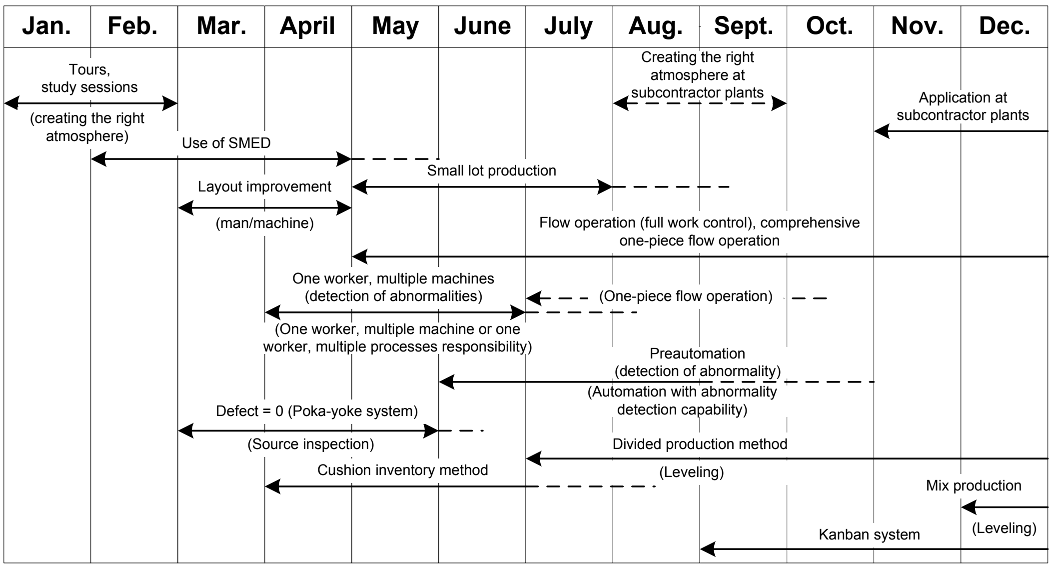


Figure 2.3: Plan for introducing the Toyota Production System by Shingo (1989).

Shingo (1989) emphasizes that to implement TPS, everyone must have a clear understanding of the basic principles of the system. Everyone must understand that TPS seeks to eliminate stock, the waste of overproduction, by looking at the underlying need for stock, e.g. machine failures, and finding ways to prevent these from reoccuring. Top management must be dedicated and committed to shutting down machines and if needed entire production lines in the quest for solving the root cause of problems. Shingo further suggests that the first elements to be implemented are SMED, zero defects, layout improvements, and a cushion inventory system to gradually transition into lower stock operations. He argues that this is important before one-piece flow and *kanban* is attempted, since that would be too big a shock to a system used to having large amounts of inventory. By lowering the inventory in steps, problems are surfaced and can be dealt with in a non-overwhelming manner. The system should thereafter increasingly link processes together in a flow, going towards one-piece flow operations. Workers should start operating several machines or processes at once going towards a state of pre-automation. The production schedule should the be leveled, and a *kanban* system should be implemented. Finally, the system should be extended to the suppliers. He points out that this is an example for how to implement TPS in a hypothetical company and while it is generally applicable, the timing may vary by situation.

Finally, Shingo (1989) emphasizes that the two things that are more critical than anything else to the success of lean is that top management is committed and has the zeal needed to carry through to the end, and that everyone understands the techniques and principles of the system.

2.4.2 Smeds (1994) - Managing Change Towards Lean Enterprises

The 'Generic Framework for the Management of Change towards a Lean Enterprise' by Smeds (1994) takes a change management perspective on the process of implementing lean in an organization. The framework is seen in figure 2.4. Smeds (1994) explains that the

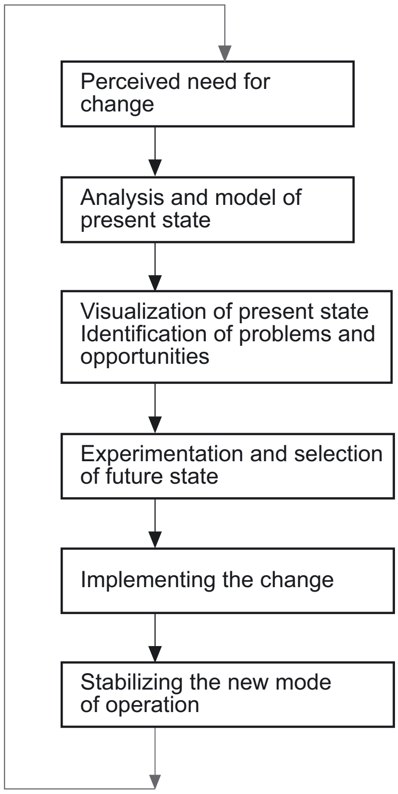


Figure 2.4: Framework for managing change towards a lean enterprise by Smeds (1994).

process starts with a strategic vision and an umbrella strategy to guide the actions of the change projects. The second phase is the analysis of the present state which should be done by change agents and managers. Business strategies and processes should be analyzed, and subsequently benchmarked against best practice lean, which serves the purpose of revealing the potential. Concrete business processes for the change projects should be chosen. In the following phase, a team of all the relevant managers and employees (including operators) should be assembled in a workshop, and efforts should be made to visualize the current state and reveal problems and opportunities, which Smeds (1994) suggests could be done through the use of simulation games to create a shared understanding between all the participants. Thereafter, based on the ideas from the simulation game, new future state ideas should be developed and tested by simulation. Towards the end, a design should be selected for the project to implement. During the implementation, management should ensure feedback and communication about the progress of the change initiative, both for managers to keep track and for the employees on the project to feel motivated. Quantitative lean-esque performance measures should be implemented to track the progress of the change project, and the results made visible to the rest of the organization to inspire them. Finally, the new modes of operation should be stabilized, which also entails iteration of the process to fix those issues that were never resolved in the previous phase. Smeds (1994) argues that the effort of stabilizing the new mode of operations requires continuous innovation on a day-to-day basis. The lean performance parameters should be made permanent and visible to everyone. When the benefits of incremental improvements start to dwindle, the process should start over again.

Smeds (1994) further emphasizes top management support as being critical throughout the entire change process, and that the facilitators of the workshop are the key change agents. If they are employed by the organization they should act as change agents during the implementation process. However, the really important people are the operators - as innovators in the workshop, and afterwards as operators and improvers of the new process.

2.4.3 Womack and Jones (1996) - The Lean Leap

The framework by Womack and Jones (1996) takes a primarily organizational point of view on the lean implementation effort, as well as incorporating elements of change management. The framework is shown in figure 2.5.

TIME FRAME FOR THE LEAN LEAP

PHASE	SPECIFIC STEPS	TIME FRAME
Get started	Find a change agent Get lean knowledge Find a lever Map value streams Begin *kaikaku* Expand your scope	First six months
Create a new organization	Reorganize by product family Create a lean function Devise a policy for excess people Devise a growth strategy Remove anchor-draggers Instill a “perfection” mind-set	Six months through year two
Install business systems	Introduce lean accounting Relate pay to firm performance Implement transparency Initiate policy deployment Introduce lean learning Find right-sized tools	Years three and four
Complete the transformation	Apply these steps to your suppliers/customers Develop global strategy Transition from top-down to bottom-up improvement	By end of year five

Figure 2.5: The 'Lean Leap' by Womack and Jones (1996).

In order to get started with a lean transformation, Womack and Jones (1996) argue that the main task is to overcome the inertia present in the organization. In order to do this, the organization needs to find a capable change agent who is ready to introduce truly fundamental change. Detailed lean knowledge must also be acquired. To get momentum on the change effort, a crisis must either be seized or created, to motivate the organization. The company should focus on the lean effort and not larger strategic decisions such as whether to be in industry at all because, either way, a successful lean transformation can't *hurt*. The process of mapping all the organization's value streams should then be commensed, and as soon as possible, the change effort should begin with *kaikaku* in an important and visible activity. The company should avoid lengthy analysis, planning and simulation. The objective should be immediate results, as employees seeing things actually *changing* will create momentum. When momentum is established, activities should be extended to the rest of the chosen product family's value stream. Flow should be established, and then pull and *kanban*. Then, the scope should be expanded from the shop floor to other processes such as ordering.

When success is achieved in one value stream, it is important not to make the mistake of thinking that all that is left to do is to copy to the other value streams. Management must begin thinking about organizational changes. The company should consider reorganizing by value stream rather than the traditional organizing by function. They further suggest the establishment of a 'lean function' to house all the lean resources, which reports directly to the change agent. A plan for what to do with excess people freed up by process improvements must be developed at the outset of the lean effort. One way to do this is to devise a growth strategy for what to do with the excess resources. Furthermore, people (especially managers) who work against the lean transformation must be removed. A culture of improvement or a 'perfection mind-set' should be created, which should include the perspective that not succeeding is acceptable, while not trying is not (Womack and Jones, 1996).

In the third phase, business systems should be installed to complement a lean organization. Policy deployment should be utilized to align efforts with the company's strategic goals, lean accounting in the form of e.g. Activity Based Costing should be introduced, and the reward policy should be based on the firm's performance rather than individual performance. The organization should be made more transparent, with information available to everyone. This involves the creation of information boards which provide information about the value streams in real-time. Additionally, knowledge about lean should be provided to everyone, at the time it is needed (just-in-time) (Womack and Jones, 1996).

The fourth phase is to expand lean beyond the plant. The suppliers and customers should be involved and convinced to implement lean, although this should not be attempted until the company has fixed its own processes first. This includes consolidating the supplier base and developing meaningful long term relationships with a select few key suppliers. Lean should also be extended from the plant to a global scale, i.e. other plants and value streams in other parts of the world. Finally, the company should gradually transition from top-down driven lean to bottom-up driven lean as employees at all levels become more and more accomplished in lean and continuous improvement. Managers acting as coaches and employees being proactive is the key to sustaining lean (Womack and Jones, 1996).

2.4.4 Nordin (2011) - Organizational Change in Lean Implementation

Like Smeds (1994), the framework by Nordin *et al.* (2011) also approaches the implementation of lean from a change management perspective. Their framework is shown in figure 2.6 on the next page. Nordin *et al.* (2011) explain that every change effort starts with some sort of driver for the change. This leads into the cycle of making the organization ready for the transformation that is to be initiated. This is achieved by ensuring that everyone understands the need for change, by having clear and consistent leadership and direction or

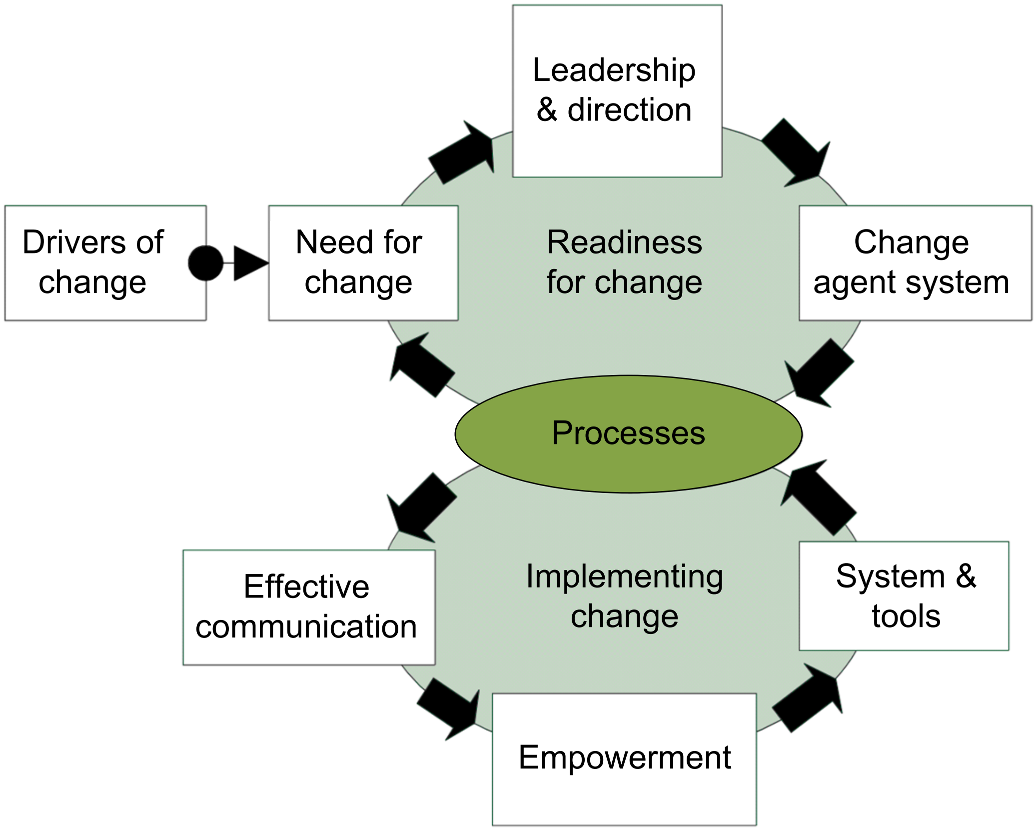


Figure 2.6: Organizational change framework in lean manufacturing implementation by Nordin *et al.* (2011).

strategy, and good change agents. Nordin *et al.* (2011) emphasize that it is important that those that lead the change projects need to have the right skills, competencies and aptitude to implementing lean.

When readiness for change is ensured, the organization should get start on implementing the lean tools and techniques in the organization's processes. It is important that the tools are not adopted in isolation, since lean manufacturing is a system. The implementation of lean itself is critical. The changes that are made must be aligned with operational issues so to create understanding for how the changes will affect the company and what must be done to meet the challenges of implementing lean. In the implementation loop, effective communication, empowerment of workers and control systems play key roles. Continously sharing knowledge and information in a transparent way to faciliatate learning as well as continuously reviewing and evaluating the lean effort will ensure a smooth transition from previous management principles to a lean philosophy. If the company can quantify the effort and progress towards lean, it increases the odds of initial and enduring success.

Nordin *et al.* (2011) further argue that the change process must be seen as dynamic, since lean should be regarded as an intended direction rather than a static state. An understanding of lean as well as the change management principles should be present in the organization. Finally, they highlight strong leadership, a capable team and effective communication as the critical success factors of a lean implementation.

2.5 Shortcomings of the Existing Frameworks

There are several shortcomings with the existing frameworks for lean implemenation. First of all, there is a lack of consensus about what the key elements are to a lean implementation, as none of the frameworks build on the others. Shingo (1989) focuses on the technical elements of the production system, Smeds (1994) and Nordin *et al.* (2011) focus on management of the change process, and Womack and Jones (1996) focuses on organizational changes and the process of change. None of the frameworks describe the whole. Even the framework by Womack and Jones (1996) which is arguably the most comprehensive, fails to provide detailed information about the technical elements, and neglects a number of elements mentioned by others regarding both the organizational and change management aspect. Taken together, the frameworks begin to give a clearer picture of the entirety of elements that must be considered and managed for a successful lean implementation. Yet, even then there are elements of lean which are not mentioned in any of the frameworks, i.e. operational stability and a problem solving culture. Furthermore, there is a lack of research on the topic of the sequence in which the different elements should be considered. In conclusion, these are the main shortcoming of the existing literature and frameworks on lean implementation:

- The existing frameworks do not build on each other and address different aspects of lean implementation, with no framework considering all the relevant aspects.
- There are important elements of lean production which are not incorporated in any of the existing frameworks.
- The sequence in which elements of lean should be implemented is not well researched.

2.6 Conclusion

This chapter reviewed the existing literature on lean, change management, and lean implementation frameworks. Evidently, lean production is not merely a toolbox of techniques and practices. It is a complex system with both technical and organizational elements. The cornerstone of the system is a philosphy or a culture of continuous improvement, problem solving, and the involvement of everyone. The tools and practices of Just-in-Time and *jidoka* are the tangible, technical elements of the system, and these require basic operational stability to function effectively. For successful implementation of lean, both the technical and organizational elements and the synergies between them must be considered, and the change process must be managed effectively through competent change management. The existing frameworks for lean implementation do not adequately cover all the relevant aspects, and thus there is a need for a framework which fills this gap in the literature.

CHAPTER 3

Methodology

3.1 Introduction

This chapter explains the methodology of this research. The case study method is described, the motivation for choosing the case study method is explained, and the type of case study chosen is presented. Subsequently, the research design behind this research is presented, describing the process of data selection, data collection and data analysis. Finally, the validity and reliability of this research is addressed.

3.2 Research Method

For this research, the case study method was chosen as the primary research method.

3.2.1 The Case Study Method

According to Yin (2009), a case study is an empirical inquiry that:

> *"Investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident."*

Furthermore, because the phenomenon at study is often hard to distinguish from its context, case research employs special strategies for data collection and analysis:

> *"The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis."* (Yin, 2009).

There are several common misconceptions about the usefulness of case study research (Yin, 2009; Flyvbjerg, 2006). Amongst these are: case studies are not rigorous enough as a research method, one cannot generalize based on a single case, it is hard to summarize a case study, case studies are more useful for theory building rather than theory testing, case studies contain a bias for verification, and that general, theoretical (context-independent) knowledge is more useful than concrete, practical (context-dependent) knowledge. However, these have been resolved or allayed by authors such as Yin (2009) and Flyvbjerg (2006).

3.2.2 Reason for Choosing a Case Study

Recall that the main question of this research is:

> *How can the implementation of lean production be effectively planned and managed?*

Yin (2009) states that a case study is most appropriate when the research question is in the form of 'how' or 'why', when the researcher has no control over behavioral events, and when the focus is on contemporary rather than historical events. In this case, all three of these conditions were met, which made a case study the obvious choice for a research method. Furthermore, Stuart *et al.* (2002) argues that the case study method fits research within the field of operations management (OM) better than more traditional, quantitative research methods because of the complex nature of the subject under study. Each organization's operations system is built up from a number of a subsystems, each of which adds complexity to the point that the variety among operations systems becomes staggering:

> *"The conceptual frameworks that form the OM body of knowledge must recognize all the contingencies and factors that distinguish one firm's operations (and its situation) from others. (...) If we are to develop well-grounded theory, our methods must reflect this reality. (...) Case studies remain one of the best ways to make sure that researchers are making valid observations and contributions to the OM body of knowledge."* (Stuart *et al.*, 2002).

3.2.3 Choice of Type of Case

There are several different types of case studies. The main two dimensions of case study research are the purpose of the case study and the number of cases (Yin, 2009). Regarding the purpose of the case study, there are three different categories pertaining to the different stages of theory building (Stuart *et al.*, 2002). These are:

- Discovery/description/understanding
- Mapping/relationship building
- Theory validation/extension/refinement

The purpose of this research is in the second category of mapping/relationship building, as the research focuses on exploring the relationship between a number of both technical, organizational and change management variables in a lean implemention process and the success of the lean implementation. Handfield and Melnyk (1998) suggest that for this purpose, an in-depth case study is appropriate. Therefore, this type of case study was chosen.

Regarding the number of case studies, a case study can take the form of either a single-case study or a multiple-case study (Yin, 2009). For this research, it was chosen to make a single-case study of the process of implementing lean production in one of the three plants of Grundfos Manufacturing Hungary. This was chosen for two reasons. Firstly, the researcher had access to the single case chosen to an extent that would not have been possible with additional cases, as the researcher was a participant-observer in the case for nearly half a year. This allowed for a level of depth that would otherwise not have been possible. Secondly, the choice of a single case was based on the premise that the case of Grundfos

Manufacturing Hungary represents the 'typical case' of a company in the process of implementing lean manufacturing, and thus the findings from the case study can potentially be generalized to the average manufacturing organization (Yin, 2009). The arguments for this being the case are that the following characterizes the case of Grundfos Manufacturing Hungary:

- Large, Western company (over 1,000 employees).
- Stable, mature, repetitive manufacturing industry (the pump industry).
- Some experience with sporadic application of lean elements and having failed at these attempts.

Thus, the case is believed to be typical of large Western companies in stable, repetitive manufacturing industries with no previous lean success (either due to a lack of initiatives or due to failed initiatives).

3.3 Research Design

The main research question for this study was:

How can the implementation of lean production be effectively planned and managed?

The main objectives of this research were:

1. To develop a framework for the effective implementation of lean production which considers both operational, organizational and change management aspects.
2. To refine this framework using a case study.
3. To provide examples of how to operationalize the the framework.

Figure 3.1 illustrates the approach taken to answer this study's research question and achieve the research objectives.

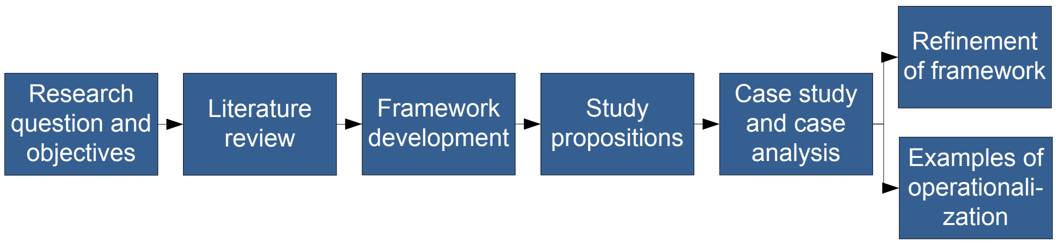


Figure 3.1: Approach taken to answer this study's research question and complete its objectives.

From the research question, a literature review of relevant literature pertaining to lean production, change management and existing frameworks for lean implementation was conducted. It was concluded that there were several shortcomings with the existing frameworks for lean implementation. Based upon this, a framework for implementing lean production was developed. As investigating all elements of the entire framework was beyond the scope of the study, four propositions were formulated to guide the case study data collection. Based on the case study, the case was analyzed with respect to these four propositions. This resulted in findings pertaining to the four propositions as well as further additional findings, which resulted in a refinement of the framework based on the case analysis. The case study also provided several examples of how to operationalize some of the more intangible elements of the framework, i.e. creating a problem solving culture.

3.3.1 Data Selection

The framework represented a multitude of possible propositions about how lean production should be implemented. It was assessed as infeasible to address each of these within the scope of this research. Therefore, it was chosen to formulate four propositions. These were:

1. Unambiguous management support from the beginning as well as active leadership throughout the implementation process is necessary for a successful lean implementation.

2. Establishing basic operational stability is a prerequisite for the implementation of the more advanced technical elements of lean.

3. A culture for waste reduction through continuous improvement and problem solving should be established early on in the lean implementation process.

4. For a lean implementation to succeed, a critical mass of lean knowledge, both theoretical and practical, must be present from the outset, and training which is in correspondence with the elements being implemented must be provided.

The choice of these four propositions was made based on two criteria: newness compared to existing frameworks, and feasibility of investigating these within the scope and timeframe of the chosen case study. All four propositions fulfilled these criteria. The case study was then carried out to test these propositions. The unit of analysis chosen for the case study was the process of implementing Grundfos Shopfloor Excellence (lean) on the MG 90/100 motor production line in GMH1.

3.3.2 Data Collection

The case study concerns the implementation of Grundfos Shopfloor Excellence (GSE), which is the name of Grundfos' corporate lean iniatitive, on the MG 90/100 production line in the first plant (GMH1) of Grundfos Manufacturing Hungary (GMH). The case study is based on three different *methods* of data collection, which effectively provide a triangulation of methods (Yin, 2009). These methods are participant-observation, interviews and documents. Furthermore, each of the three methods relies on several different *sources*, hence providing a triangulation of sources as well. The research methods and sources are illustrated in figure 3.2.

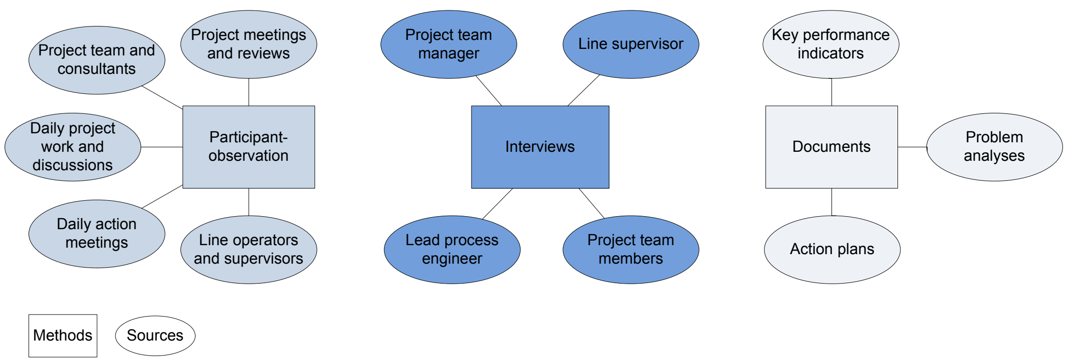


Figure 3.2: The research methods and sources used for data collection.

The actual implementation on the MG 90/100 line ran from 1 July 2010 to 8 February 2011. This was split into two phases: 1 July - 30 October (the initially planned timeframe for the project), and 1 November - 8 February (the re-launch of the project with the assistance of an external consultancy company). For the first part of the case study up to 1 November 2010, the case study relies on documents and interviews only, as the author was not involved in the project until it was re-launched on 1 November. For the second part of the case study, all three methods of data collection were used. The actual collection of the data was carried out in three phases, with the first phase being participant observation, and the second two being phases of interviewing people relevant to the project. It is important to note regarding the interviews that these are loosely structured and do not strictly follow the flow of the questions as presented in the appendices. This is due to the fact that interviews as part of case study research should be guided conversations rather than structured queries (Yin, 2009). Documents were gathered continuously, but principally at the same time as the interviews were conducted.

Upon request from the case company and the interviewees, no names are mentioned in the case study and case study analysis. The relevant people are referred to by position, and interviewees are referred to as e.g. 'a member of the project team' in order to ensure that comments critical of management or others cannot be directly traced back to a single person, allowing everyone to speak their mind freely.

Data Collection Part 1: Participant Observation

In the period from 1 November 2010 to 8 February 2011, the author was a full-time participant in the lean implementation project in the case company in the form of an internship. According to Yin (2009), participant-observation has both benefits and drawbacks. Participant-observation gives the opportunity for the researcher to perceive reality from the viewpoint of someone inside the case study rather than external to it - something that many have argued is invaluable in accurately portraying a phenomenon (Yin, 2009). It may also be the only way for the researcher to be able to conduct the case study. The trade-offs are that the researcher risks bias as he may be required to advocate certain procedures that are contrary to good research practice, or that he may come to support the group or phenomenon being studied, thus jeopardizing objectivity (Yin, 2009). It may also be difficult for the researcher to adequately fulfill the role of observer when also being a participant, as it may be hard to find time to take notes, and as it may not always be possible to be at the time and place that is of the most interest to the case research (Yin, 2009).

In the case of this research, the trade-off was simply necessary; there was no other way that the case study would have been possible. Therefore, the trade-offs had to be tolerated. The first problem of bias was not an issue since the author was an assistant on the project and thus rarely asked to assume a role in conflict with the research objectives. The problem of 'support bias' is a legit concern, and in order to prevent this, the researcher made a point of continous vigilance to remain objective. Finding time to take notes was not a problem, again because the author was in the position of an assistant, and thus naturally assumed the role of an observer when discussions occured. Notes were taken daily, except for days where no project related activities occured, and the author always carried his notebook around. It was, however, not always possible to be at the time and place most interesting to the case study, as the assistant was generally not invited to higher level management meetings concerning the project. A transcript of the notes from the researchers notebook can be found on the attached CD-ROM.

Data Collection Part 2: Interviews with Project Team Members

Interviews were carried out with the three members of the project team towards the end of the project in early February 2011. These interviews were a mix of a focused interview and an in-depth interview. According to Yin (2009) in-depth interviews are used to ask key respondents about facts concerning the case, and to ask for opinions and insights from the respondent, which thereby becomes an informant. Key informants are often critical to the success of a case study (Yin, 2009). Focused interviews should be used when the purpose is to corroborate certain facts that may already be known (Yin, 2009). Since conducting more than one interview at the time was not feasible (the team members were not obliged to subject themselves to interviews and therefore the researcher relied on goodwill in persuading them to set aside time for it), it was necessary to combine the two interview forms in one interview. The questionnaire for these interviews can be found in appendix A.

Data Collection Part 3: Interviews with Project Team Members, Local Team and Manager

The final phase of data collection was carried out when the researcher returned to the company $2\frac{1}{2}$ months after the completion of the first lean project. In this phase, two of the three original team members were interviewed (unfortunately the last team member was unavailable), as well as the Lead Production Process Engineer, the primary Supervisor, and the project team's direct manager, who served as both manager of GMH's technical department as well as the plant manager of the second of the company's three plants, GMH2. Again, for the same reasons as in the first round of interviews, the interviews were a mix of focused and in-depth interviews. The questionnaires can be found in appendices B and C.

3.3.3 Data Analysis

The case study was analyzed based on the four propositions derived from the framework. The analysis was made using pattern-matching and explanation building techniques. The propositions propose that the lack of a given variable will lead to lack of success implementing lean, while the presence of a given variable will instead lead to success. In the analysis of the propositions it is argued whether a given variable was present or not in each phase of the project, and the expected result (success or failure) is compared to the actual result (success or failure) by means of in-depth explanation building. Based on this, it is concluded whether the case study findings supported the propositions or not.

3.4 Validity and Reliability

For case study research, four aspects of validity and reliability are relevant. These are: construct validity, internal validity, external validity and reliability (Yin, 2009).

Construct validity is concerned with whether the case study accurately measures the constructs it set out to measure. Yin (2009) suggests the use of multiple sources of evidence as a tactic to ensure construct validity. In this research, triangulation of both sources and methods was utilized.

Internal validity concerns whether the causal relations suggested by the research can actually be substantiated. In order to increase internal validity, Yin (2009) suggests the use of pattern matching and explanation building techniques. For this research, a mix of these techniques was used.

External validity regards whether the study's findings are generalizeable beyond the immediate case. As the chosen case is considered a typical case, the findings are considered generalizeable to the population for which the case is typical (see section 3.2.3 for more information) (Yin, 2009).

Finally, reliability is concerned with the ability of others to replicate the same results if following the same procedure as was used to conduct this case study (Yin, 2009). In order to heighten reliability, a case study database was developed which includes the original interview audio files, summaries of each interview, scans or electronic versions of the documents used as sources, and a transcript of the participant-observers notebook. This case study database can be found on the attached CD-ROM found in the back of this thesis. An overview of the contents of the CD-ROM can be found in appendix D.

3.5 Conclusion

This chapter presented the case study method and the reasoning behind the choice of conducting an in-depth single case study. Additionally, the research design regarding data selection, data collection and data analysis was presented. Lastly, the validity and reliability of the research was discussed.

CHAPTER 4

Lean Implementation Framework

4.1 Introduction

This chapter presents a comprehensive framework for lean implementation based on a synthesis of the existing literature on lean, lean change management, and existing frameworks for lean implementation. The constituent technical, organizational and change management elements of a lean implementation are summarized, and the sequence in which these should be implemented is discussed. The framework is presented, and each phase of the framework is explained. Finally, four propositions are formulated to guide the empirical part of this research.

4.2 Recapitulation of Elements

The literature review in chapter 2 provided ample evidence that a lean implementation must consist of both operational technical elements, i.e. the shop floor tools and techniques of JIT and *jidoka* as well as the techniques to ensure the operational stability for these to function, and organizational elements, i.e. a culture for continuous improvement and problem solving, team organization and training. It was also highlighted that the process of implementing a change to a lean company, like any other change initiative, requires conscious and effective change management. Table 4.1 on the following page lists the technical, organizational and change management elements relevant to successful lean implementation. There are a few overlaps between the organizational elements and the change management elements, as elements such as employee involvment, training, and alignment of supporting systems with lean appear as both elements of the system itself, and important change management drivers.

4.3 Sequence of Implementation

Having established the elements of the framework, an important discussion which has garnered fairly little attention is the temporal sequence in which these elements should be implemented. Åhlström (1998) argues that there *are* natural sequences to the implementation of manufacturing tools and techniques because of systemic relationships, and because

Elements in a lean implementation		
Technical	Organizational	Change management
Operational stability - Vertical information systems using information boards - 5S - Standardized work - Problem solving tools - Preventive maintenance / TPM - Leveled production (*heijunka*) **Built-in-quality/zero defects (*Jidoka*)** - Autonomation - Error-proofing (*poka-yoke*) - 100% inspection - *Andon* (stop the line) **Just-in-Time and pull** - Value stream mapping (VSM) - *Kanban* - Cell layout - One-piece flow - SMED - Line balancing (*yamazumi*)	- **Philosophy** of waste reduction, continuous improvement, respect for people and long-term thinking - **Culture** of continuous improvement, problem solving and *genchi genbutso* - **Role of management** is to support and involve employees - **Teamwork** and team leaders - Reorganization by **value stream** - **Training** in lean and multi-skilling - **Alignment of supporting systems** (measurement, reward, accounting, HR, org. structure etc.)	- Strategically sound **plan** for implementation, and **continuous review** to adjust to the dynamics of the process - **Clear vision** and burning platform - **Top management commitment** and **active leadership** - Capable **change agent** - **Employee involvement** - Effective **communication** - **Critical mass of lean knowledge** and expertise available - Provision of adequate lean knowledge at all levels through **training**

Table 4.1: Technical, organizational and change management elements in a lean implementation according to existing literature.

resources for implementing these tools and techniques are often limited, thus necessitating a prioritization of resources, which directly translates into a decision of what elements to address first. The rational argumentation of Shingo (1989) also showed that some elements must naturally precede others (e.g. Shingo's great focus on reducing set-ups through SMED before applying *kanban* and similar tools). Bhasin and Burcher (2006) also hypothesize that one of the main problems in implementing lean is the lack of adequate project sequencing.

4.3.1 Technical Elements

A greater part of the lean literature argues that there is no one best way to implement lean. Pavnaskar *et al.* (2003) assert that the tools of lean are often used wrongly in several ways: the wrong tool may be used to attempt to solve a problem, people may attempt to use a single tool to solve *all* their problems, and they may also try to use all the tools (or the same set of tools) to solve every problem. He argues that each of these is wrong: the problem must determine the choice of tool, and the problems are different from situation to situation. Smalley (2006) supports this notion as he argues that everyone must always assess their unique situation, and start from their greatest point of need. This is the approach advocated in the implementation framework by Smeds (1994) as the backbone of the process of implementing lean, and by Womack and Jones (1996) as they argue that an important first step is value stream mapping. However, Convis (2001) advises caution and urges that companies must not lose focus of the fact that the lean tools make up a synergistic system of elements, a point that is also made by Shingo (1989). These two points of view are not incompatible: the point of departure for the lean journey must be based on the given situation, yet the goal must be to eventually implement the entire system.

While the stance that 'problem determines tool' is generally accepted, there are quite a few sources that advocate that there is a basic, logical sequence in which these elements should *generally* be implemented. In his plan for implementing TPS, Shingo (1989) advocates early adoption of SMED, zero defects, layout improvements and to follow that up with a gradual transition into *kanban*, flow and autonomation, and eventually leveling the production schedule. Allen (2000), however, suggests that there are five phases to the implementation of lean tools and techniques: stability, continuous flow by means of a standardized process, synchronizing the production system to takt time, pull through *kanban*, and finally leveling (*heijunka*). The point concerning the need for establishing operational stability before attempting other lean tools is suggested by quite a few sources. Herron and Braident (2007) argue that if TPS is to deliver results, basic 'manufacturing best practice' or *genba kanri* is needed first: problem solving activities and *kaizen*, standardized work, 5S, basic preventive maintenance and SMED. Smalley (2006) also emphasizes the need for basic stability, which he describes as stability within the 4Ms (manpower, machines, materials and methods), as the absolute first thing to implement when seeking to become lean. He states:

> *"(...) many firms I visit are stuck in first gear on their initial lean efforts. They are trying to create flow but can't get traction. There are many reasons for this lack of progress (...) but an overlooked and recurring pitfall that I'm seeing more often is a lack of 'basic stability' in manufacturing operations. Quite simply, processes can't flow because key pieces of equipment are broken down."* (Smalley, 2006).

> *"(...) veterans of Toyota comment that certain pre-conditions are needed for a lean implementation to proceed smoothly. These include relatively few problems in equipment uptime, available materials with few defects, and strong supervision at the production line level. And these are precisely the problems that I see manufacturers still struggling with today. (...) What Toyota learned the hard way is that in the beginning of a transformation you need lots of basic stability before you can succeed with the more sophisticated elements of lean."* (Smalley, 2006).

The argument for the need for stability in methods i.e. standardized work is taken further by Huntzinger (2006) who asserts that lack of standardized work and inability to hold it once established is the very reason lean initiatives stagnate. Figure 4.1 on the next page illustrates the point: without standardized work, changes and their impact quickly fades because people eventually return to their habitual ways of working. Marchwinski (2006) lends more weight to the argument for basic stability first as he states that: *"You can't build a house of production unless you have a strong foundation (...) so we started with creating stable processes."* He is emphatic that the starting point of lean is a heavy dose of problem solving to assess issues with machine stability, lack of standard procedures etc., and that it is really very simple; you do not need a large scale TPM program, but just basic focusing on downtime problems and ironing those out (Marchwinski, 2006). While all these sources assert that the point of operational stability is lost on many would-be lean practitioners, there is evidence to support it in one of the 'bibles' of lean by Ohno (1988):

> *"Kanban is a tool for realizing just-in-time. For this tool to work fairly well, the production processes must be managed to flow as much as possible. This is really the basic condition. Other important conditions are leveling the prodcution as much as possible and always working in accordance with standard work methods."*

Ohno (1988) repeatedly points to the significance of standardized work and stable, uninterruped process flows to the success of TPS.

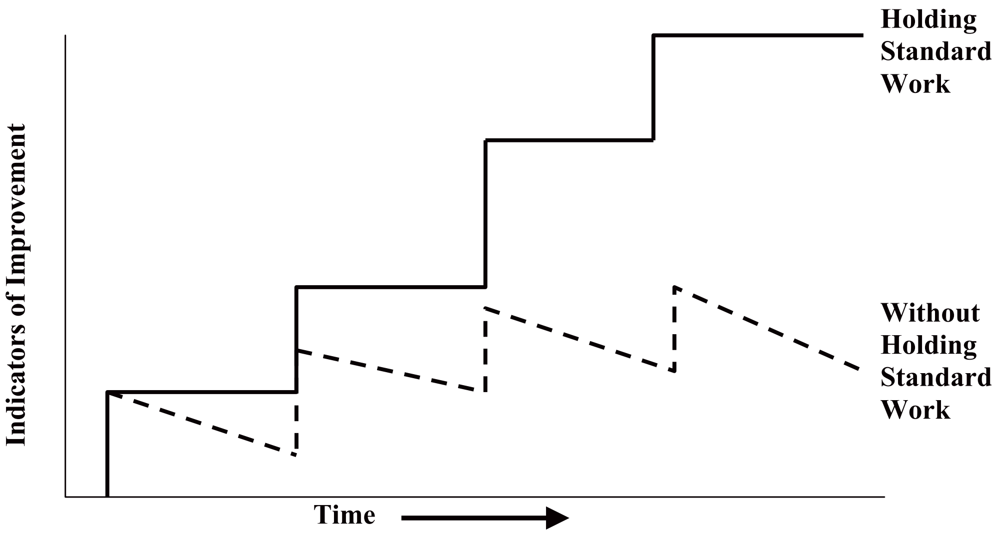


Figure 4.1: The effects of holding and not holding standardized work (adopted from Huntzinger (2006)).

In the Toyota House of Production, *heijunka* is also part of the 'foundation' for the house. Curiously enough, most authors agree that this is not something to pursue early on as it is simply infeasible to sufficiently level both production volume and mix as long as instability is high and set-up times are long (Monden, 1983; Shingo, 1989; Allen, 2000).

Some authors argue that achieving zero defects is another important early technical element in the implementation of lean. Åhlström (1998) showed that achieving zero defects early on was a high priority in the case he studied, and further points to the logic by Ferdows and Meyer (1990) who argue that enhancing quality is the first step towards making lasting manufacturing improvements. The case for zero defects as an early element is also indirectly made by the many sources who argue for basic process stability first, as minimizing the amount of scrap and rework is an important contributor to a stable and predictable process. Indeed, Hancock and Zayko (1998) highlight both early stability, zero defects and setup reductions as necessary preconditions for realizing the benefits of lean.

There is little discussion concerning line balancing, one-piece flow, pull and *kanban*: these elements are the more advanced elements of lean and rely on the other elements to function, and therefore naturally come last in a lean implementation. Indeed, the literature is virtually unanimous on this point (Monden, 1983; Ohno, 1988; Shingo, 1989; Allen, 2000).

4.3.2 Organizational Elements

There are several sources that point to the importance of making the lean initiative a simultaneous 'attack on two fronts': the technical and organizational level. Liker (2004) suggests to start with the technical elements, but quickly follow up with organizational changes. Lathin and Mitchell (2001) argue for a technique that they dub 'joint optimization', which seeks to simultaneously implement lean technical elements and organizational changes. Jørgensen *et al.* (2007) laments the lack of focus on organizational elements in lean implementations, and argues that there is a great synergistic potential between the technical and organizational side of lean.

The previous section described how many sources argue that each organization is unique in terms of context and problems. This indirectly makes a case for the need for an early adoption of a problem solving and continuous improvement culture. This point is made by Allen (2000) who singles out problem solving as the key element of the initial phase of establishing process stability. Indeed, he suggests that the entire process of implementing lean depends on systematic problem problem solving: *"(...) determine the problems causing a given situation, and their root cause, then decide what to do."* Liker and Rother (2011) and Spear and Bowen (1999) argue that this aptitude for systematic problem solving as well as the desire to continuously challenge existing standards to improve them and reach new, better standards are the very essence, 'the DNA', of the Toyota Production System. Shingo (1988) explains that TPS evolved out of need, because of the specific challenges, or problems, that Toyota faced at the time. Thus, many of the actual tools were invented, developed and refined in response to specific production problems. Ballé (2005) chimes in as he contends that the only way to go further than the initial low hanging fruits is by means of rigorous problem solving.

Several sources emphasize that training or acquisition of lean knowledge is a constant in a lean implementation. Womack and Jones (1996), Stamm (2003), and Liker (2004) all highlight the need for the presence of a 'critical mass' of lean knowledge in the organization from the outset. Specifically, several of these sources point to the need for having a designated change agent from the start, and someone who can provide the knowledge, which may or may not be the same person. Shingo (1989) and Convis (2001) emphasize that employees at all levels must understand the principles and techniques of lean. Liker (2004) suggests that the training should be with a heavy focus on learning by doing. Taken together, this indicates a need for training in the lean principles and techniques at all levels in the organization, with a focus on learning by doing, which suggests that the training should follow a sequence similar to the adoption of the techniques, i.e. training in a specific tool is given prior to the implementation of that tool.

Åhlström (1998) and Åhlström and Karlsson (2000) both found that establishing teams of multi-skilled workers as well as a team leader structure were important early initiatives. This is supported by Ohno (1988) and Shingo (1989) who emphasize the need for multi-skilled workers and a teamwork spirit as important for the success of a flow-based, balanced line. Curiously, Womack and Jones (1996) point to the need for a 'lean function' to house all the 'lean people' in the organization, all the while contradicting themselves by promoting a reorganization around value streams. Since the establishment of a lean function is not supported by any other sources, the reorganization around value streams is seen as more important (Liker, 2004). As regards the organizational supporting systems, there is a general consensus that these alignments should be considered in the latter stages of the lean implementation (Womack and Jones, 1996; Liker, 2004). The same is the case for the extension of lean activities to the supply chain (Shingo, 1989; Liker, 2004), with Womack and Jones (1996) explicitly stating that this should not be considered until the internal processes have been fixed.

4.3.3 Change Management Elements

Very little literature is available concerning an actual sequencing of the change management elements. An explanation for this can be found in the fact that several of the change management elements must continuously be managed in parallel throughout the implementation process, and as such the notion of a sequence does not really make sense. This is the case for elements such as communication, reviewing and revising the implementation plan according to the changes in context, top management's active leadership throughout the process, and involving and empowering employees to participate in the implementation initiative.

There are some discrete elements that must be in place *before* the change process can even begin, though. Shingo (1989) recognizes this as he states that there is a need to create the right atmosphere before the lean initiative is undertaken. Most important of these is top management commitment/support, which must be present from the very beginning for any initiative to succeed (Im and Lee, 1989; Sohal, 1996; Worley and Doolen, 2006). The framework by Nordin *et al.* (2011) points to the need for leadership i.e. top management commitment, as well as direction, as necessary to acquire adequate readiness for change. The point about direction in the form of a vision and a solid implementation plan from the get-go is backed up by authors such as Hines *et al.* (1998) and Stamm (2003). The framework also highlights the need for acquiring a capable change agent before the change processs can commense (Womack and Jones, 1996; Carreras *et al.*, 2009). Finally, points are also made about the need for lean knowledge and training as well as organizational realignment; as previously noted, these elements are treated as part of the organizational dimension of the implementation process due and disregarded here to avoid rendundancy.

4.4 The Framework

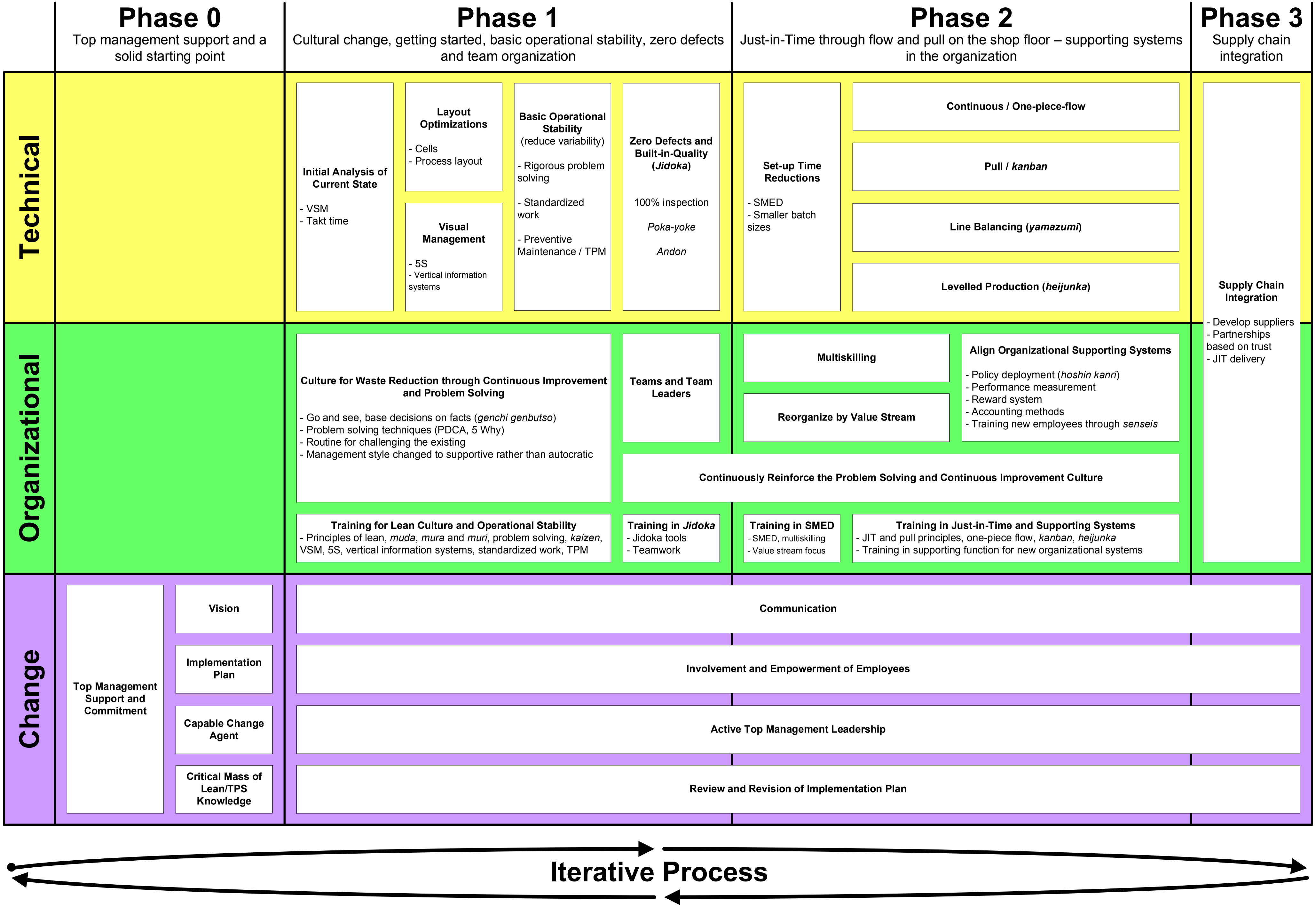
From the literature review the constituent technical, organizational and change management elements of implementing lean production have been identified, and in this chapter, the optimal sequence in which these elements should be implemented has been discussed. Based on this, a comprehensive framework for implementing lean production has been developed. The framework is seen on page 55. As can be seen, four phases to lean implementation are suggested. It is important to note that it is the *content* and *sequence* of the elements that is relevant to this framework. As such, the *size* of the blocks is not to be taken explicity - the duration of particular elements (outside the rough time frame that is the phase that the elements are located in) is not the subject of this framework. The motivation for the inclusion of the elements in the framework as well as the logic behind the sequencing were both established in the previous sections of this chapter. Therefore, the following will offer merely a brief description of each of the four phases.

4.4.1 Phase 0

The first phase is named 'Phase 0' because it is essentially a preparation phase. It involves elements pertaining to the change management category exclusively. The elements in this phase must be addressed before the actual lean transformation can begin. Top management commitment must be present, and they must establish a believeable change vision and promote it so that it gains wide acceptance in the company. An initial plan for the lean transformation must be developed, including initial milestones and deadlines, resource allocation etc. A capable change agent must either be identified or hired, and the same goes for the initial lean/TPS expertise required to establish a complete and realistic action plan as well as provide both theoretical and practical guidance during the process.

4.4.2 Phase 1

Phase 1 is the actual lean transformation 'kick-off'. A production process should be chosen which, ideally, is not only important to the company but is also in a crisis situation. On the


Phase 0
Top management support and a solid starting point
Phase 1
Cultural change, getting started, basic operational stability, zero defects and team organization
Phase 2
Just-in-Time through flow and pull on the shop floor – supporting systems in the organization
Phase 3
Supply chain integration
Technical
Organizational
Change
Initial Analysis of Current State
- VSM
- Takt time
Layout Optimizations
- Cells
- Process layout
Visual Management
- 5S
- Vertical information systems
Basic Operational Stability
(reduce variability)
- Rigorous problem solving
- Standardized work
- Preventive Maintenance / TPM
Zero Defects and Built-in-Quality (Jidoka)
100% inspection
Poka-yoke
Andon
Set-up Time Reductions
- SMED
- Smaller batch sizes
Continuous / One-piece-flow
Pull / kanban
Line Balancing (yamazumi)
Levelled Production (heijunka)
Supply Chain Integration
- Develop suppliers
- Partnerships based on trust
- JIT delivery
Culture for Waste Reduction through Continuous Improvement and Problem Solving
- Go and see, base decisions on facts (genchi genbutso)
- Problem solving techniques (PDCA, 5 Why)
- Routine for challenging the existing
- Management style changed to supportive rather than autocratic
Teams and Team Leaders
Multiskilling
Reorganize by Value Stream
Align Organizational Supporting Systems
- Policy deployment (hoshin kanri)
- Performance measurement
- Reward system
- Accounting methods
- Training new employees through senseis
Continuously Reinforce the Problem Solving and Continuous Improvement Culture
Training for Lean Culture and Operational Stability
- Principles of lean, muda, mura and muri, problem solving, kaizen, VSM, 5S, vertical information systems, standardized work, TPM
Training in Jidoka
- Jidoka tools
- Teamwork
Training in SMED
- SMED, multiskilling
- Value stream focus
Training in Just-in-Time and Supporting Systems
- JIT and pull principles, one-piece flow, kanban, heijunka
- Training in supporting function for new organizational systems
Top Management Support and Commitment
Vision
Implementation Plan
Capable Change Agent
Critical Mass of Lean/TPS Knowledge
Communication
Involvement and Empowerment of Employees
Active Top Management Leadership
Review and Revision of Implementation Plan
Iterative Process

technical level, an initial analysis of the current state should be conducted, including (but not exclusively) a value stream mapping. Based on this analysis, the starting point should be decided - the organization should not spend large amounts on time on 5S if their 5S situation is already state of the art, obviously. As a general rule, however, the first technical elements after the initial analysis should be to optimize the layout of the process to a cell or process layout, get rid of unnecessary stock etc., and simulatenously implement 5S and other visual management techniques such as information boards to highlight performance and problems. Next, rigorous problem solving and preventive maintenance must be applied to solve the issues concerning manpower, machines and materials, and standardized work should be developed to stabilize methods and form a solid basis for improvement. Thereafter, attention must be devoted to solving the quality problems inherent in the process, and basically building quality into the process through the use of the *jidoka* techniques of *poka-yoke*, *andon* and 100% inspection.

On the organizational level, the chief objective of phase 1 is to change the organizational culture to one that sees waste reduction and continuous improvement as the primary goals of the company, and problem solving as the primary means towards this goal. The culture should be one that emphasizes challenging the existing way of doing things, basing your decisions on facts through the practice of getting out of the offices and down to the shop floor to 'go and see', and where it is the operators who must be the main driver for improvement - and management must do what is in its power to support them. This culture must be reinforced continuously throughout the implementation process as well as after the main implementation is over. Towards the end of phase one, the shop floor operators should be reorganized into teams with team leaders and given actual responsibility and autonomy to make improvements to their daily work. The training in phase 1 is centered around the technical and organizational elements that comprise it: the basic principles of lean and waste, the problem solving and continuous improvement routine and the techniques to operationalize it (PDCA, '5 Why' for example), visual management (5S and information boards), preventive maintenance and standardized work - both the purpose of it, actually developing it, and training everyone in the new standard work procedures. They must also be given training in the *jidoka* tools and team-building training.

4.4.3 Phase 2

In phase 2, the transition towards a leveled flow and pull system can begin. This process starts with the application of SMED techniques on key machinery to reduce their set-up times and thereby allow for smaller batch sizes and consequently an increasingly levelled production schedule. The processes of implementing one-piece flow, pull/*kanban*, line balancing and *heijunka* are simultaneous. The reason for this is that one-piece flow and *kanban* are alternatives; you pull where you cannot flow (Rother and Shook, 1998). Line balancing could technically be a step in itself before one-piece flow, as a balanced line is needed to produce in a one-piece flow. However, this whole process of implementing these four things should be seen as a gradual transition into a lean production system through iteration of these four elements; level the production as much as possible, balance the line as much as possible, introduce *kanban* and one-piece flow where applicable, and then iterate on this design by starting over to improve even further.

At the beginning of phase 2, attention should be given to making the workforce multi-skilled so that they can handle a multitude of jobs on the line, since this is a necessity for line balancing and effectively reducing waste in the form of waiting employees. The organization should begin its adjustment to an organization that complements a lean production system by reorganizing from a functional organization to a value-stream oriented organization. Towards the end of phase 2, the process to align the organizational supporting systems with a lean company should be undertaken. The job concerning the creation of a problem solving continuous improvement culture that begun in phase 1, however, is not a one-off thing; attention must be paid to continuously reinforcing this culture day-in, day-out. Again, the training given in this phase corresponds with the elements in the phase: initial training in SMED techniques to operators and engineers. Value stream principles and team-building training to the new value-stream based supporting teams. Finally, training in JIT and pull principles, one-piece flow, *kanban* and *heijunka*, with all levels of the organization getting the basic training, and detailed training given to those who are to crunch the numbers and do the design part of the new JIT system. Obviously, training in new procedures etc. should also be given to the supporting elements of the organization whose systems are changing, e.g. accounting and HR.

4.4.4 Phase 3

Phase 3 is the phase where the company begins to work across supply chain borders to introduce lean to customers and suppliers. Unless the company is in a position to 'bully' its suppliers or has unlimited resources to support them in their lean efforts, this often entails a consolidation of the supplier base into a smaller amount of key, trusted suppliers that the company is comfortable with investing in. The company should aid its supply chain partners in their lean efforts by sending their lean champions to help and guide. The primary goals are to reduce the waste in logistics by reducing stocks, lead times and quality problems between the supply chain partners.

4.4.5 Continuous Elements

There are some elements in the framework which are continuous and not specifically related to any phase. One of these is the element of training, although the content of the training varies from phase to phase. Training should be done through theoretical teaching followed *immediately* by practical learning by doing under the guidance of the more knowledgeable teachers. The extent of the training (both how many and how much) is debatable, and will likely depend greatly on the amount of resources available to the organization. However, as a general rule, the basics should be taught to everyone, at all levels of the organization. Detailed training can generally be selective and aimed at those who will be driving the design and implementation of the new systems. For example, it makes sense that maintenance personnel be given more training in preventive maintenance than others, and that production engineers are given more training in SMED techniques.

The rest of the elements that transcend phases are change management elements: communication, involvement of employees, active top management leadership and review and revision of the implementation plan/strategy. These must be addressed continuously throughout the implementation process; in other words, these things must always be present.

Finally, at the bottom of the framework is a symbol indicating that this is an iterative process. This cannot be stressed enough: the initial conversion to a lean organization may be presentable in a framework such as this, but the process does *not* end with the extension of lean into the supply chain. No one is ever 'done' with lean; it is a continuous process towards becoming the perfect organization. The drive to uncover problems, solve them and improve must be continuous, and the tools, techniques and elements of the framework should be used as appropriate to continue becoming ever more lean.

4.5 Research Propositions

As the author did not have access to a case in which he could control events, testing the framework was, regrettably, impossible. However, the framework itself is essentially a collection of propositions about how the implementation of lean should be planned and managed effectively. Of the multitude of potential propositions, the following four were formulated and chosen for further investigation in this research:

1. Unambiguous management support from the beginning as well as active leadership throughout the implementation process is necessary for a successful lean implementation.
2. Establishing basic operational stability is a prerequisite for the implementation of the more advanced technical elements of lean.
3. A culture for waste reduction through continuous improvement and problem solving should be established early on in the lean implementation process.
4. For a lean implementation to succeed, a critical mass of lean knowledge, both theoretical and practical, must be present from the outset, and training which is in correspondence with the elements being implemented must be provided.

The decision concerning which propositions to investigate was based mainly on two criteria: newness compared to existing frameworks, and feasibility of study within the available case. The latter criteria naturally ruled out propositions pertaining to most of the later-process elements such as establishing JIT, aligning the supporting systems and the organization, and supply chain integration; simply because it was beyond the scope of the research to follow an implementation process long enough for these elements to come into play. This put the natural focus on the earlier framework elements.

Proposition 1 consists essentially of two elements: the need for initial top management support, and the need for active leadership throughout the process. This proposition was chosen because the element of top management commitment, despite a lot of literature suggestings its importance, was only present in one of the four reviewed frameworks. The element of active leadership was not present in any of the frameworks, and generally, the literature on the topic is very conceptual. Consequently, this was an opportunity to investigate the importance of top management commitment and active leadership and possibly how it might be operationalized.

Proposition 2 was a natural choice given the large amount of sources that highlight operational stability as of extreme importance, yet the glaring lack of this element in any of the existing frameworks. There was also a lack of empirical evidence on the topic, as most of the sources that emphasize operational stability are anecdotal in nature, e.g. former Toyota managers or lean practitioners.

Proposition 3 concerning the establishment of a culture for continuous improvement and problem solving was chosen because of the fact that while it had been emphasized as the very basis of a lean organization, there were differing suggestions for when this element should be introduced; for example, Womack and Jones (1996) suggest to implement a perfection mindset in the middle of their framework sequence-wise, and lean learning late. On the other hand, several sources suggested it should be one of the first things to give attention to. Therefore, it was found prudent to investigate whether this is actually the case.

Finally, proposition 4 was chosen because only the framework by Womack and Jones (1996) incorporate the element of initial lean knowledge, and no one is specific regarding what constitutes sufficient lean knowledge. Training was a missing element in the existing frameworks as well, and the literature on the topic of training limited itself to emphasizing the need for training, giving little attention to the specifics of what, when, who and how.

4.6 Conclusion

This chapter presented a comprehensive framework for lean implementation which was developed from the existing literature on lean, change management and lean implementation. The constituent elements of an effective lean implementation were summarized, and the sequence in which these elements should be implemented was discussed. Based on this, the framework was developed, presented and explained. Based on four elements of the framework of particular interest, four propositions were formulated to guide the empirical part of this research.

CHAPTER 5

Case Study: Grundfos Manufacturing Hungary

5.1 Introduction

This chapter introduces the case of a lean implementation project on the MG 90/100 production line in GMH1 in Grundfos Manufacturing Hungary. The background for the project is explained, and the two phases of the project are described. Finally, the post-project state of the line is reviewed.

5.2 Background

This case study follows a lean implementation project on the MG 90/100 motor production line in GMH1. To understand the starting point of the project, background information about Grundfos Manufacturing Hungary, previous lean activities in the company, the Grundfos Shopfloor Excellence program and the MG 90/100 line is necessary.

5.2.1 Grundfos Manufacturing Hungary

Grundfos Manufacturing Hungary (GMH) is a Hungarian manufacturing company producing pumps and motors for pumps. It is a subsidiary of the global Danish company Grundfos, one of the world's leading pump manufacturers. The first operations in Hungary were established in 2000 with the first factory, known as GMH1, in Tatabánya, 60 km from the capital city of Budapest. GMH1 manufactures motors for Grundfos pumps. In 2003, operations in Hungary were expanded as part of Grundfos' pump production was moved to GMH2, a newly built second factory right next to GMH1. In 2007, a third factory known as GMH3 was built in another city, Székesfehérvár. In 2011, GMH employed over 1,500 employees in all three factories combined.

Grundfos Manufacturing Hungary's top level organizational structure is seen in figure 5.1 on the following page. The general manager together with the managers of the staff functions as well as the three plant managers make up the company's top management. Note that the plant manager of GMH2 also occupies the position of technical director, the manager of the technical department, which consists of a group of engineers and a group of facility personnel.

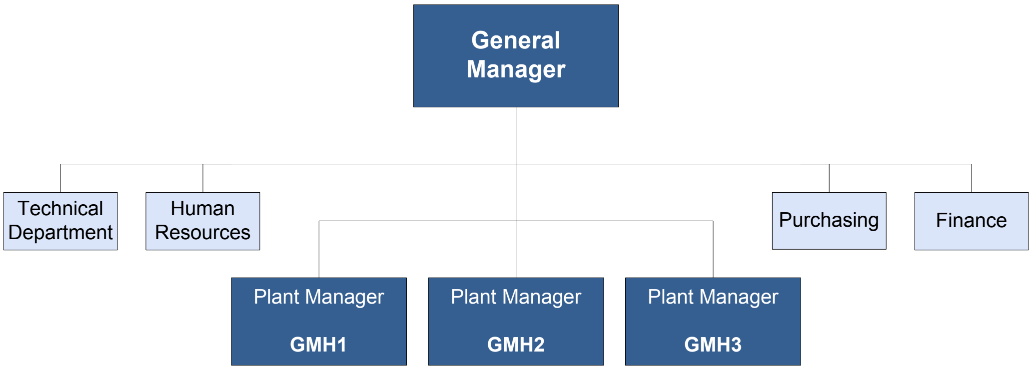


Figure 5.1: Top level organization structure of GMH.

5.2.2 Grundfos Shopfloor Excellence

In 2008, the Grundfos group decided to start systematically implementing lean elements in all the of concern's production companies. This materialized into 'Grundfos Shopfloor Excellence' - Grundfos' corporate lean programme, shorthanded as 'GSE'. Up until that point, there had been sporadic lean activities throughout Grundfos, but it had been on a volunteer basis and quite intangible and unstructured. This was also the case in GMH1, where several attempts had been made at lean-esque implementations, with little success.

History of Lean in GMH1

The first lean activity in GMH1 was in 2003, when a position of 'lean engineer' was created. During this period there was some employee training in lean concepts, some lean activities e.g. 5S, TPM and SMED, some Six Sigma training, and some attempts at introducing a *kanban* system. The effect was both mediocre and temporary, and the initiatives soon dissolved. In 2006, a corporate lean strategy was developed on Grundfos group level, and the subsidiary companies were told from the headquarters in Denmark to begin lean activities. As a result, the technical department in GMH1 conducted an analysis of the current state of lean in the company in late 2007, and devised a lean strategy for the company for 2008. This strategy involved a range of initiatives on plant level, with many different responsibles. The elements included a plant-wide suggestion program for continuous improvement, layout improvements in certain areas after value stream mapping exercises, and overall equipment effectiveness (OEE) measurement on some machinery which were clearly marked visually as bottlenecks. A lot of energy was also put into raising the lean awareness in the company. Posters listing the seven wastes were put up, overhead projectors were set up in the production which showed basic lean information such as the seven wastes and lean principles, and a 20-page 'lean booklet' which was basically a mini-encyclopedia on lean tools was developed and handed out to every employee. However, after a good start, the continuous improvement programme quickly died out - employees stopped making suggestions as they never saw any action taken on their suggestions. Improvement activities stagnated and were abandoned, and resources were devoted to other things. In 2011, the old bottleneck markers were still up, but they were outdated and no longer represented the actual bottlenecks. OEE was still being measured, but no one used the data.

Creation of GSE

The idea for the Grundfos Shopfloor Excellence program came out the corporate headquarters in Denmark in 2008 in the form the 'GSE House', a conceptual structure similar to the Toyota House. The GSE House is seen in figure 5.2. While it was a good idea, it was not followed up by any action for the following year.

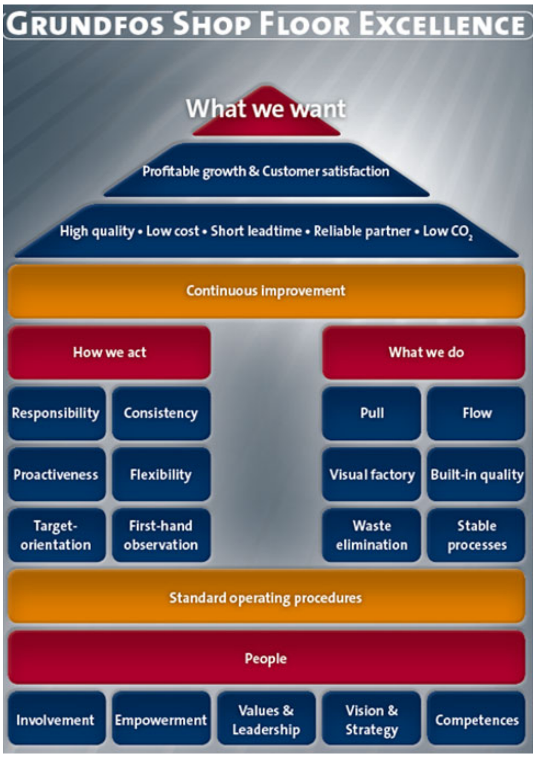


Figure 5.2: The GSE House.

In 2009, the GSE program begun to take shape. The headquarters in Denmark identified and documented 25 lean tools that might be useful in Grundfos, and from these, five elements henceforth known as the 'five main elements' of the GSE were chosen. These elements were mandatory, and to be implemented in every Grundfos production company. The elements were: 5S, VSM, PM (preventive maintenance), OEE and SOP (standard operating procedures - basically a standard worksheet). These five main elements are seen in figure 5.3.

Figure 5.3: The original 'five main elements' of GSE.

The task of implementing GSE in GMH was given to one of the technical departments chief engineers, who was allocated one day per week allocated for the GSE project. After almost a year with very little results in GMH, a decision was made in early 2010 by the corporate management of the Grundfos group that the production lead time and work-in-process (WIP) inventory of the production companies should be reduced by 30% by mid-2012. This made top management in GMH decide that if the GSE project was to ever materialize into those kind of results, it would be necessary to establish a dedicated GSE project team. In May 2010, a team of six engineers (including two chief engineers) was assembled, and the Grundfos GSE team was established. Beyond a few pages of theoretical description of the various lean tools, the Grundfos Group had provided very little guidance as to how the companies were to go about implementing these elements. Consequently, GMH's new GSE team spent May and June of 2010 developing the base for the Hungarian GSE program: templates, documents, etc. The team made self-assessments of their lean and change management knowledge levels, rough timeplans for the projects, project resource requirements and so forth. Top management decided to start two simultaneous projects in two of the three plants. Three of the team members would start on the MG 90/100 motor production line in GMH1, while the other team would start on the NB pump production line in GMH2. Henceforth, the three members working on the MG 90/100 project is referred to as 'the GSE team'.

5.2.3 The MG 90/100 Line in GMH1

This case focuses on the project in GMH1 on the MG 90/100 motor production line. GMH1 is the motor production facility. The MG 90/100 line produces Grundfos MG motors, also known as standard motors, with a diameter of 90mm or 100mm. Regardless of variant, customers can choose to buy the motor alone, or with an electronic frequency converter attached to it (referred to as an MGE motor). Examples of both motor types (MG and MGE) as well as the standard components of an MG 90 motor can be seen in figure 5.4. The main components of the motor are: stator, stator housing, shaft with rotor, and the end shields and flange, since all these are manufactured by previous processes on the line or in CNC machining cells in the plant. The remaining elements are assembly components purchased from suppliers.

The MG 90/100 line is naturally divided into two major segments: the stator production, and the motor assembly line (referred to as the stator line and the motor line). The layout of the line can be seen in figure 5.5 on the next page. The stator line is, essentially, three small cells close to each other: the D75, D85 and D95 cells. The numbers refer to the diameter in milimeters of the stator that the cells produce. Approximately 65% of the demand is for D75 stators, with 30% for D85 and 5% for D95. The D95 process is almost completely manual production, while semi-automatic machines are used for some of the stations on the D75 and D85. Still, both of these processes are also primarily manual. The final operation in the stator production process is the lacquering of the stator. There are two lacquering machines, with one dedicated to the D75 line, and the other being shared by the D85 and D95 lines. Between the stator production area and the motor assembly area there are two intermediate operations. The first is a 'baking' process, for which there is only one machine. The second operation is machining of the stator-in-house, for which there are two CNC machines. Finally, at the motor assembly line, the motor is assembled from the stator-in-house, the shaft and rotor and all the other elements seen in figure 5.4. The motor area consists of two separate assembly lines. One line is capable of producing both MG and MGE motors (because it has a tester for the frequency converters for the MGE motors), whereas the other is only capable of producing the standard MG motor. Throughout the case, only one of these lines (the first) was permanently in use.

The organization structure relevant to the MG 90/100 line is seen in figure 5.6 on page 66. At the highest level is the plant manager of GMH1. Under him there are two production managers, one for the MG (standard motors) area, and one for the MS (submersible mo-

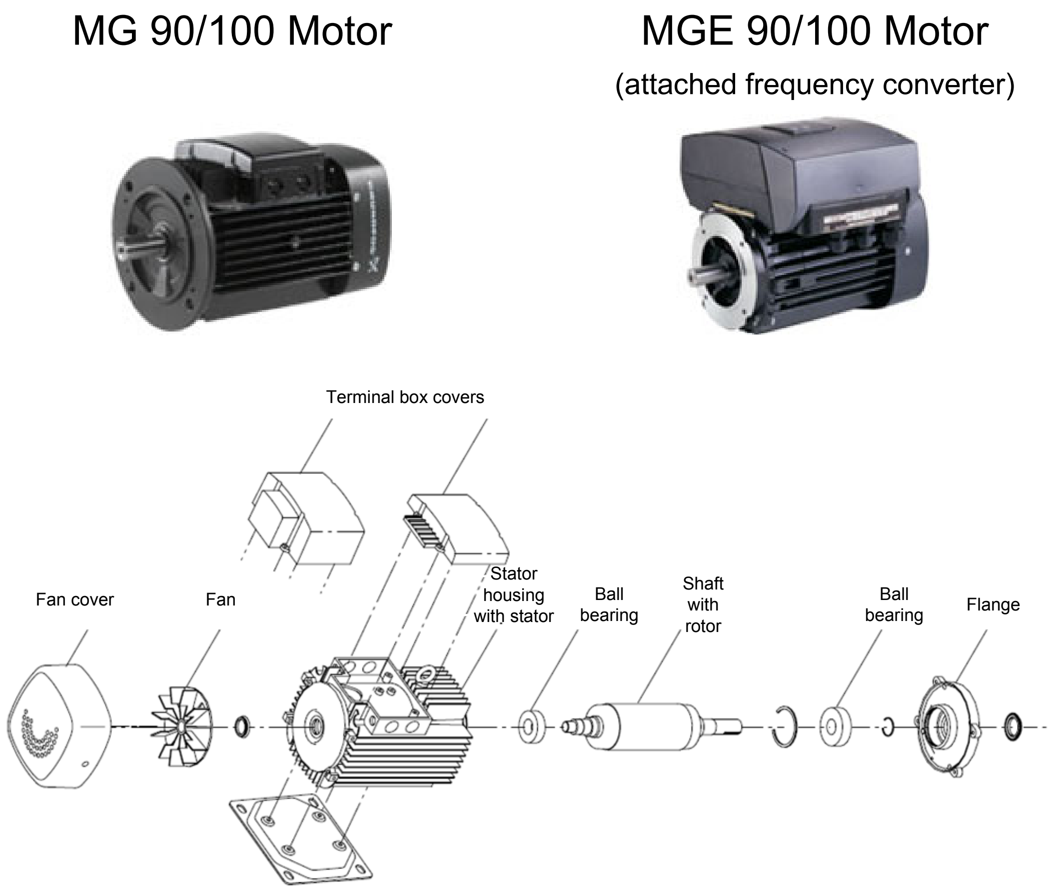


Figure 5.4: Examples of the MG and MGE motors and their main components.

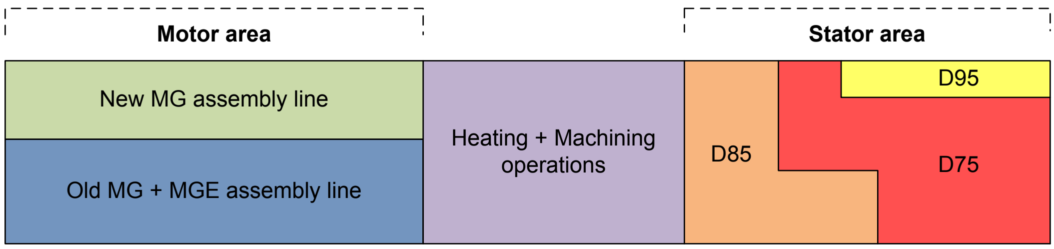


Figure 5.5: Layout of the MG 90/100 motor production line.

tors) area, as well as a logistics manager and a technical manager. However, from the start of the MG 90/100 GSE project, there was no production manager - instead, the plant manager acted temporarily as both production manager and plant manager. The production in GMH1 was running 24 hours a day, in three shifts of 8 hours each: morning (6-14), afternoon (14-22) and night (22-06). Therefore, the MG 90/100 line had three supervisors who all reported to the MG production manager. Each shift also had two coordinators reporting to the supervisors: one for the stator area and one for the motor area. Each production line also had a 'lead production process engineer', who was supposed to be the main driver of improvements to the process. Under the technical manager was a quality engineer and a PT (production technology) engineer, and under the logistics manager was a logistics planner. Together, these people made up the 'local team' of the MG 90/100 line. The same local team was also responsible for another line, the MG 71/80 line. It is important to note that the team did not have a team leader; all the team members reported to their respective managers in their respective functions. No one in the team had formal authority over the others. Except for the planner, the entire local team was relatively new to the company and/or the line, with neither of them having more than six months of experience in their current positions. The local team and the GSE team together is henceforth referred to as 'the project team'.

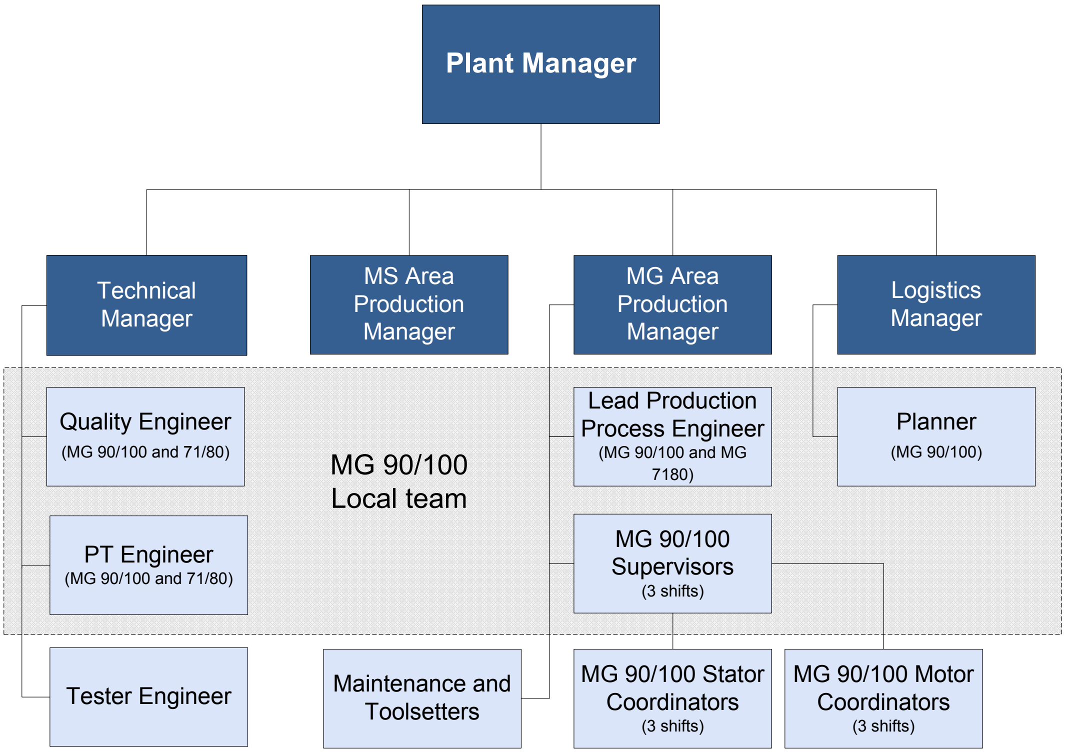


Figure 5.6: Organization structure of the MG 90/100 line.

5.3 Phase 1: First Attempt at Grundfos Shopfloor Excellence

The implementation of lean in the shape of GSE on the MG 90/100 line eventually came to consist of two phases. The first phase was from July to October 2010 and was driven by the GSE team with the assistance of the local team.

5.3.1 The Project Charter

To define the scope of the project, a project charter was developed. The project was supposed to run from 6 July 2010 to 30 November 2010. The initial purpose of the project was to implement the five main elements of GSE on the MG 90/100 line, as well as take actions to reduce the lead time and WIP of the line. Based on this, the 3-man GSE team developed the project charter. However, as plant management began discussing the contents of the project charter, more and more goals, targets and KPIs were added to the project. Because the GSE concept was new to the team members, they were not really sure what they were supposed to achieve. A member of the GSE team says:

> *"Every factory was waiting for us to solve their issues (...). We basically let the local management give us project goals - the business case part of it. (...) We basically got a brainstorming of what kind of issues needed to be solved on the line."*

Because the team was not comfortable questioning the management's decision, the project charter ended up as a veritable wishlist of goals and KPIs. Many of these KPIs were also quite intangible as, for many of them, there was neither a baseline (an idea of the current state) nor a method for measurement, but only a target.

> *"There were KPIs which were not measured, KPIs that even the management didn't know what was, KPIs which were not followed, KPIs which were not directly affected by the line, and a lot of non-KPI issues that were simple issues that the PT or engineering department should be able to solve by themselves as their daily work."*

The GSE team had also prepared an estimation of the necessary resource requirements in the form of time from the MG 90/100 local team. The GSE team requested an allocation of 80% of the local team's time to the project. However, management did not agree with this assessment, and granted the team half of the time requested. The initial timeframe for the project, 6 July to 30 November 2010, remained unchanged. Management, the GSE team, and the local team all signed the project charter.

5.3.2 Project Approach

The initial approach from the GSE team was to focus on the five main elements, as this was the original purpose of the project. To kick off the project, an involvement workshop was held with the local team, the supervisors and coordinators, and some key operators. This workshop involved an exercise of point *kaizen* on a simple production process simulated by the use of LEGO bricks, as well as a 'paradigm shift' movie, to change the mindset of the local team to one of improvement. The local team was given classroom-style training on the theoretical basics of the five main elements.

The plan for introducing **preventive maintenance** was to largely outsource the work to a company specializing in preventive maintenance. The maintenance leader of GMH1 was made local responsible for the project, and worked on it in collaboration with the consulting firm. The element of introducing **standard operating procedures** was placed into the hands of the assistant of the technical manager of GMH1, who, together with a student, begun developing work instructions in cooperation with the operators from the different workstations. Thus, the GSE team was left to attend primarily to three elements: OEE, 5S and VSM. Concerning **OEE**, the team developed a definition of OEE as well as methods and templates for measuring and calculating it, and after teaching the operators how to use these, begun measuring OEE on several machines in the process. The **5S** implementation started with an audit of the current state of 5S on the line. From this, the team developed an action plan for the implementation of 5S, which was then handed over to the local team - specifically the lead production process engineer and the supervisor - who were then in charge of implementing the changes. The last element, **VSM**, took up a lot of time as the team had to develop a current state and a future state map from scratch. From the VSM, a large number of necessary actions were identified (around 30). These included the introduction of a *kanban* system for the motor area to pull the necessary stators from the stator area, the introduction of *heijunka* to plan the production on some of the machines in the stator area, SMED activities on certain machines etc.

Based on the analytical work regarding 5S, OEE and VSM, a large action plan for the project was developed. Because the project charter, in essence, defined the scope of the project as solving all the problems on the production line, a large number of additional quality, planning and techical issues were added to the action plan. In the end, the plan included over

100 items. The team also introduced a problem solving board on the line, where operators could add their problems and concerns. The team started conducting so called ’5 minute trainings’ for the operators, where the shifts would receive five minutes of basic theoretical training in the different elements of lean. From August, regular biweekly reviews were held between the GSE team and their manager (the technical director of GMH) as well as the management of GMH1.

5.3.3 No Action - No Results

As the project moved into the months of September and October, it became increasingly clear that things were not going as planned. Very few items on the action plan were being finished, and more and more items were exceeding their deadlines. The GSE team held weekly 1-hour project meetings with the local team, yet according to a member of the local team, these meetings were largely fruitless:

> *"(...) they [the items on the action plan] were just checked, not pushed. (...). For one hour we came together and went through this huge list. (...) It was just checking - and complaning."*

The same elements kept being listed as ’next steps’ and ’challenges’ at management reviews, and the GSE team grew increasingly frustrated with the lack of action from the local team, while the local team grew increasingly frustrated with the huge amount of things they were supposed to implement and the amount of problems they were to fix within the short timeframe of the project. The GSE team started requesting management involvement to get the project back on track, and requesting that the managers provide the local team with more time for the project, neither of which happened. Meanwhile, the performance of the line was not improving at all. Towards the end of October, the PM element was the only element that was really on track. The SOPs were still being developed, and these were work instructions only, i.e. instructions in how to do the job, with no specifications on the sequence of steps in the operation, the cycle time of the steps, etc. As the SOPs were still under development, it would not be possible to implement them in time. The 5S status of the line had seen a slight improvement initially, but this deteriorated towards the end as the 5S status of the line dropped to the initial level. The OEE measurements were still being done, but the analyses made by the GSE team had resulted in plans for action only - no action or implementation. The same was the case for the VSM, where only a few actions had been implemented. One GSE team member said:

> *"The original three months which were given [for the project] didn’t give any results for us - basically nothing. We had all the... for example, we had the work instructions in the computer, but it was never implemented. We had the 5S table but it was never used. We knew we wanted to have a kanban system but it was never built up. We had the VSM but we were not able to reach the VSM future plan."*

As it became increasingly clear that there was no way the project would reach its targets within the project timeframe, the top management of GMH decided to seek help from an external consultancy company.

5.4 Phase 2: Consultant Suppport

While the Hungarian GSE projects had struggled, the GSE in Grundfos Denmark had been assisted by a lean consultancy company which had shown impressive results. Having witnessed these successes on a global management meeting in Denmark, the top management of GMH decided to hire the same consultancy company to assist the MG 90/100 project. The project timeframe was extended to mid-February 2011, and the project was essentially re-launched with the help of the consultants. From 1 November 2010 to 11 February 2011, one consultant would be working on the project four days per week, and another consultant acting as project manager would be working on the project two days every two weeks. The company profiled itself as a coaching company, and its approach was that the Hungarian GSE team and the local team would be *doing* while their role was to *teach* through coaching and guidance. Figure 5.7 shows the timeline of the re-launched MG 90/100 GSE project and the major events of each week.

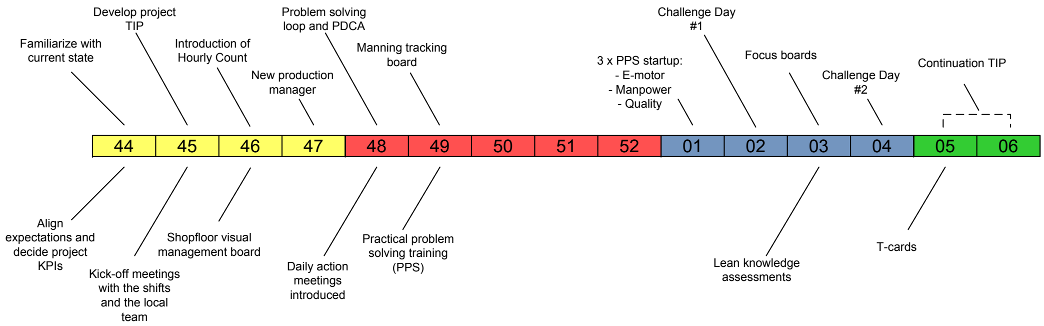


Figure 5.7: Timeline for the second phase of the MG 90/100 GSE project.

5.4.1 KPIs and TIP

The focus of the first two weeks was for the consultants to familiarize themselves with the current state, agree on project scope and expectations, and develop a project plan. The consultants insisted that the project focus on improving no more than two KPIs. Top management chose volume output and quality as the two KPIs, with the focus being on improving the output without compromising quality. The current state of these two KPIs was determined, and the project target became to increase output from the current (approximately) 590 motors per day to 700 per day (or 234 per shift). While the consultants were frustrated by what they considered an extremely short project timeframe for implementing lean, they were happy with this decision as they considered the target relatively unambitious, thus allowing for more focus to be put on actually making the line more lean. After spending some time on the shop floor and reviewing the VSM to get an impression of the current state, a tactical implementation plan (TIP) for the project was developed. The main points on this was:

1. Shop floor visual management
2. Problem solving using PDCA, PPS and focus boards
3. Challenge days
4. Lean knowledge assessments

To ensure effective project management, a project management board was erected which included an attendance register, an availability plan, the TIP, a daily action sheet, and an open issues sheet. This board can be seen in the picture in figure 5.8 on the following page.

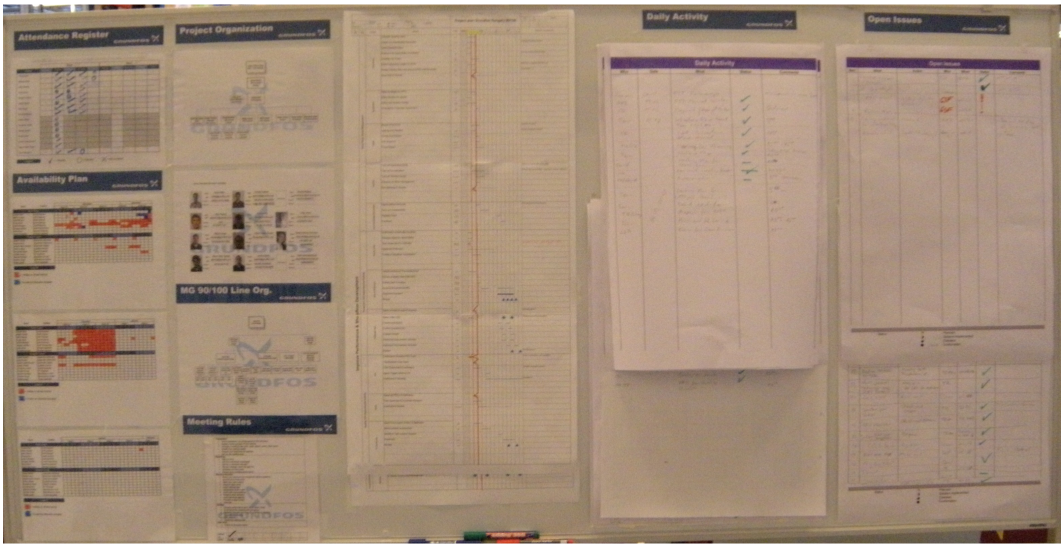


Figure 5.8: The project management board.

The GSE team, the consultants and the local team would meet every morning for 10 minutes at the project management board and, based on the TIP, plan the daily actions of every team member. An example of such a team meeting is seen in the picture in figure 5.9.

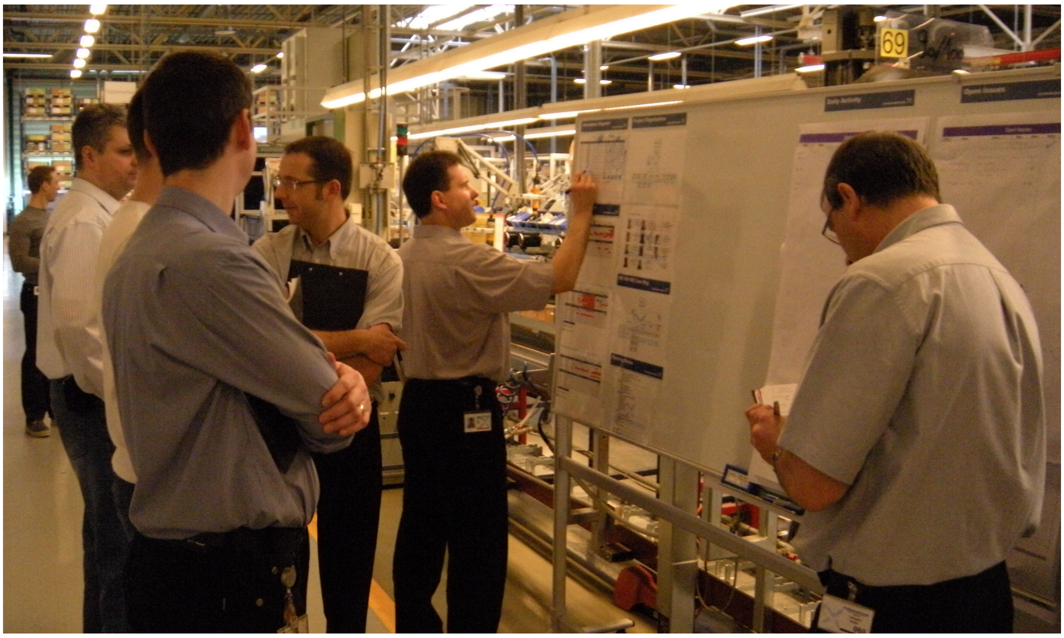


Figure 5.9: A project meeting.

Top management would meet with the team every thursday for half an hour to review the progression of the project. An information meeting was held for each of the three shifts where the new team members were introduced and the operators were informed about the re-launch of the project. Finally, a new production manager was finally hired, so the plant manager no longer had two roles to attend to.

5.4.2 Shopfloor Visual Management

The first thing that was implemented was the shop floor visual management centre. Four large whiteboards were put up next to the line. One of them was used for the introduction of the simple concept of 'hourly count': hourly registration of the output from the assembly line, comparison of the actual output versus the planned output for the hour, and a description of the problems and issues that caused the shift to miss their target for the hour. The layout of the hourly count board is seen in the picture in figure 5.10.

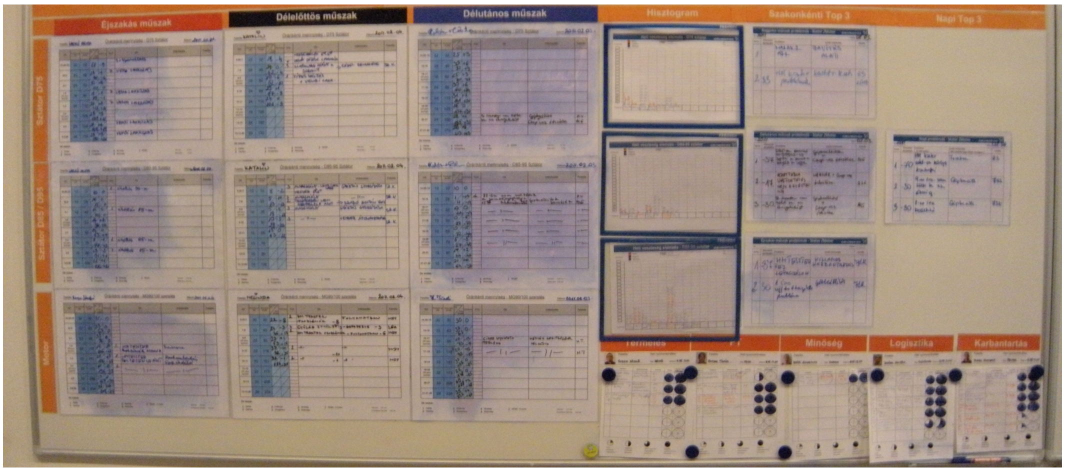


Figure 5.10: The hourly count board.

Two of the other whiteboards used for tracking KPIs. These can be seen in the picture in figure 5.11. The colored 'columns' are the different KPI categories e.g. safety, quality, productivity, etc. There were four 'rows' on the boards: monthly KPI tracking, daily KPI tracking, Pareto-diagram registering the reasons that the KPI target was not met, and finally a PDCA action plan for how to deal with these problems. The coordinators and operators were given coaching and support in how to use the new information centre.

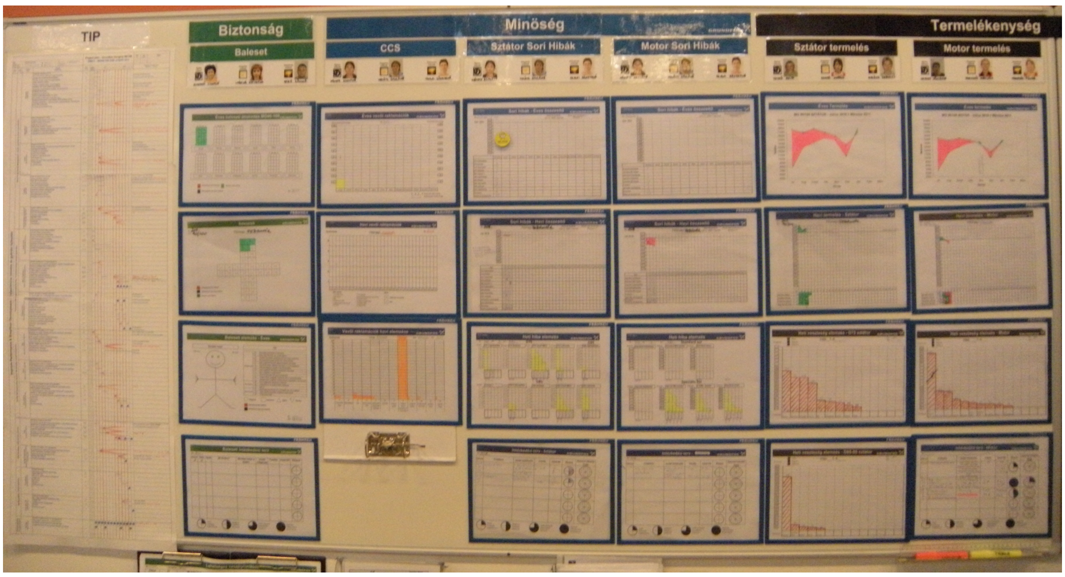


Figure 5.11: Part of the visual management information board.

Having spent November establishing the project and the visual information centre, the performance of the line did not improve much in November. The chart in figure 5.12 shows the output of the line for November. The average output for November was **605** motors per day.

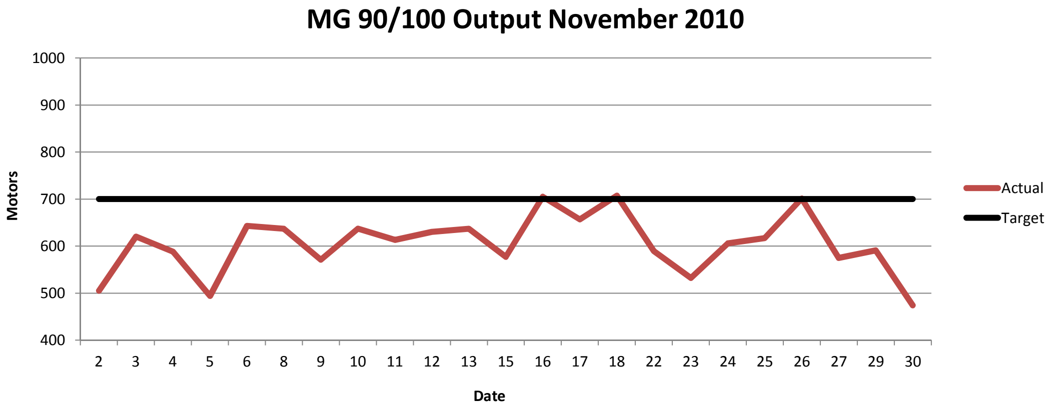


Figure 5.12: Line output November 2010.

5.4.3 Daily Action Meetings and Problem Solving

From 1 December, daily action meetings (DAM-meeting) were introduced. At the start of each shift, the operators would meet around the information centre, and the shift supervisor, coordinators and quality/safety responsibles would inform everyone about the status of the production line over the past 24 hours: how had the shift performed yesterday, how had the other shifts performed since, what had been the major issues since yesterday and especially in the last shift, and what counter-measures had been taken. A picture from such a DAM-meeting is seen in figure 5.13.

Figure 5.13: Example of a daily action meeting.

Additionally, a new meeting for the local team was arranged. Every morning from 8.15-8.30, the local team would meet at the shop floor and discuss the top 3 problems of the last

24 hours. The responsibility for fixing each of the problems would then be assigned to the appropriate person. Each support department (maintenance, logistics, quality, engineering and production itself) was given its own PDCA action plan tracking template, to keep track of the status of the issues each individual department was responsible for solving. Finally, another meeting was arranged from 8.45-9.00. Every day, the local team would meet and review the status of the action plan of one of the departments. Monday would be quality, tuesday logistics and so forth. An example of one of these local team meetings is seen in the picture in figure 5.14.

Figure 5.14: Example of the daily local team meeting.

5.4.4 Practical Problem Solving

Meanwhile, the Pareto-diagrams registering the problems causing the KPIs to miss target had been building up day by day, and a pattern was starting to emerge: the main problems regarding output were manpower issues (not enough people at work to man all the workstations, or no one with the skill to man a specific workstation) and machine issues (testers at the motor assembly line or inserters/sewing machines in the stator area breaking down). The main problems regarding quality were also being registered. In order to solve these recurring, major issues, the consultants and the GSE team gave the local team a 3-day training workshop in the technique of practical problem solving (PPS), a systematic 8-step procedure for defining a problem, measuring and analyzing it, finding the root cause, and designing permament counter-measures. This training were given right before the Christmas holidays, and in the first week of January, three PPS projects were started: one to address the manpower issues, one to address the problems with the assembly line frequency converter tester (the MGE tester), and one to address the biggest of the quality issues: a problem where the material isolating the wire from the iron core in the stator would break and cause the stator to either need rework or potentially be scrapped.

5.4.5 Challenge Days and Focus Boards

In the second week of January was the first of two planned 'Challenge Days'. The concept of a challenge day is simple: how well can the line perform under optimal conditions? For one whole shift, *everything* must be available for the line: operators of the required skill manning every workstation, a packed production plan, full raw material availability, and most importantly, full support from every department for the duration of the shift. Maintenance and toolsetters, logistics, quality, engineering - every department and their managers must live on the line for one whole shift, ready to instantly respond to any problem and solve it as fast as possible. The purpose of the challenge day is both to motivate by setting the bar higher and showing that it is actually possible to get better, and to get detailed data regarding the problems causing stops on the line. Therefore, seven observers with flipcharts were stationed around the production line to document every minute of lost time due to stoppages, material shortages, operators leaving their stations etc. For the first challenge day, the shift produced 278 motors, 20% better than the target. The main issues were breakdowns of the MG and the MGE tester on the assembly line as well as the D75 lacquering machine becoming a bottleneck for the stator area. Therefore, three focus boards were put up by these three machines. The purpose of the focus board was to measure the performance of the machine, gather data about the problems on the machine that cause stoppages (the operators would register stoppages and breakdowns, their duration and reasons), analyze the data, come up with ideas for counter-measures, and track the effect of the counter-measures by comparing the performance before and after. Each focus board was given a responsible (someone from the local team) and he and his select team of 2-3 people including the machine's operator would meet every day for 30 minutes at the focus board to work on solutions. An example of a focus board is seen in the picture in figure 5.16 on the next page. For the second challenge day, only standard motors were produced because of problems with the MGE tester. The second challenge day saw an output of 359 motors in one shift, 53% better than the target, although this can partially be attributed to the fact that MGE motors have a slightly longer cycle time than MG motors. The project target was reached several times in January, and the average output for the month was above the target of 700 units per day. The chart in figure 5.15 shows the output of the line in January. The average output in January was **703** motors per day.

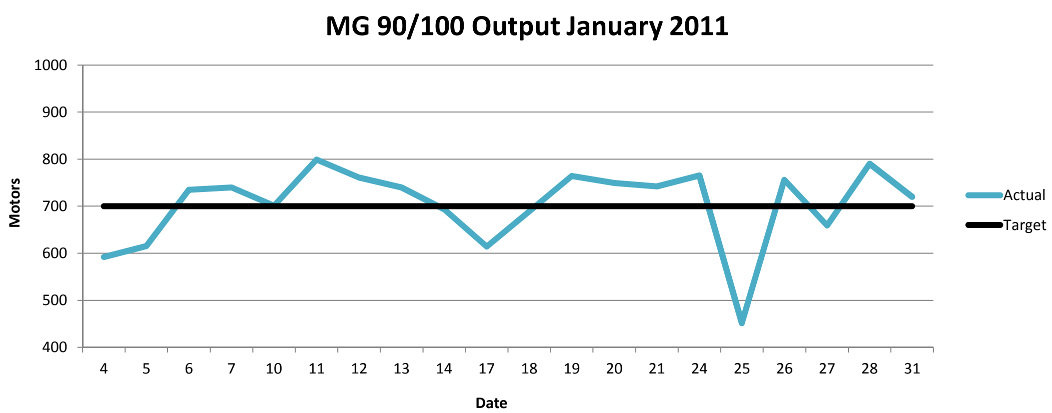
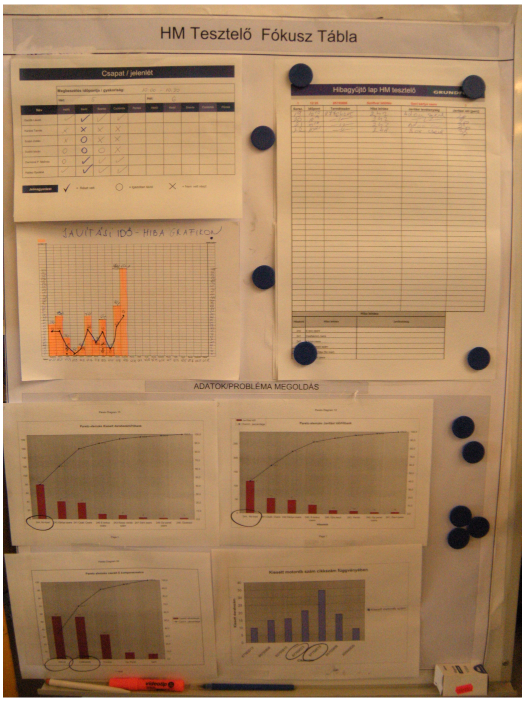


Figure 5.15: Line output January 2011.

5.4.6 T-cards and continuation TIP

Towards the end of the project, actions slowed down as the project target had already been reached, and most of the time was spent working on the PPS and focus board projects. The last element to be introduced was the T-card system. T-cards are small cards with an assignment on them to check the status of something on the line. The cards create a standardised set of instructions to ensure that a series of specific checks are completed on a regular basis, ensuring that problems are proactively prevented. Every day, different members of the local team would have one or more T-card assignments, e.g. the supervisor might have to check that the coordinators were registering the hourly count problems on the Pareto diagram. When a check has been done, the green side of the card is turned up - if it has not been done or a problem was found, the red side is turned up and the problem is registered on the action plan with a responsible person. The T-cards are useful for confirming the new visual shop floor management routines. The T-card system is seen in the picture in figure 5.16.



(a) Example of a focus board.

(b) The T-card system.

Figure 5.16: Focus board and T-card system.

During the last weeks of the project a 'continuation TIP', i.e. a time plan for the next phase of the project where the local team would continue the lean effort. The main points on the TIP were:

- Continue developing shop floor visual management
- Continue PPS and PDCA problem solving activities
- Re-introduce 5S
- Standardized processes
- Continue PM

- Line balancing (including updating the VSM and some SMED activity)
- Inventory management (establishing a *kanban* stock between motor and stator)
- Skill development for the operators

A lean knowledge assessment was also made, to get an impression of the status of lean knowledge on the local team that would continue the lean effort when the project stopped, and both the consultants and the GSE team left for other assignments. The assessment was a theoretical lean knowledge assessment. The day shift supervisor, the lead production process engineer and the production manager were tested. All three scored between 40-50%, and had large gaps especially concerning the elements of standardized work and line balancing, which were some of the next steps to be taken by the local team.

5.5 Phase 3: Local Team to Sustain and Improve

Two months after the project ended, the author returned to the company to check on the progress of the lean effort. The GSE team had left the line and been split up, with two of the members who had been working on the MG 90/100 line now working on the adjacent MG 71/80 line, and the last member working in the next-door plant, GMH2. The consultants were assisting a GSE project in the plant in Székesfehérvár, GMH3. Thus, the continuation of the lean effort was entirely up to the local team. As can be seen in the chart in figure 5.17, the performance of the line had improved even more since January. The average output for the line in March was **765** motor per day.

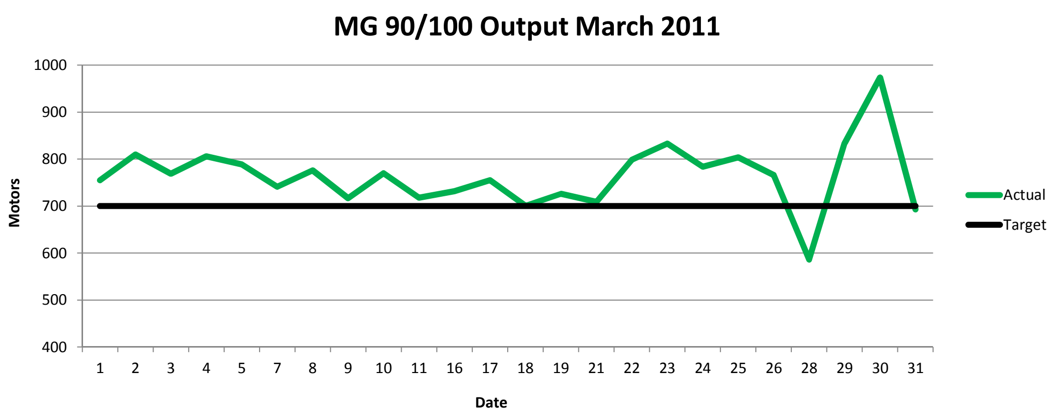


Figure 5.17: Line output March 2011.

Most of the points from the continuation TIP were underway to some extent. Standard operating procedures had been developed for the motor area, and placed onto the line above the individual workstations. A plan for balancing the line had also been developed, and the motor area had seen some actual 5S activity, with the new assembly line being in a very good state, and the old assembly line still improving. The activities that had been started during the first phase of the project (PM) as well as the second phase (hourly count, shift action meetings, problem solving etc.) were still in effect. Apart from the daily problem solving, the quality engineer had begun a new PPS project every month, and quality had improved significantly.

However, under the surface, the lean effort on the line had actually not developed much over the 2-3 months since the project stopped. While the daily problem solving was still running and the quality engineer had taken the PPS concept to heart, no other PPS had been started since the project end, and some of those that had been started during the project had not even been finished. While SOPs and line balancing had been developed for the motor area, they were mostly for show - they were not actually in use as they had never been introduced to the operators, and they had never been trained in them. Asked why they were not in use, one member of the local team replied:

> *"Because the line is running - without it. And we perform excellently."*

Because of this simple fact, the local team had also found themselves spending nearly all of their time on the new GSE project on the other line for which they were also responsible, the MG 71/80. Furthermore, since the project stopped and the GSE team and consultants had left for other assignments, no training had been given to the local team, despite the mediocre results in the lean knowledge assessments that had been conducted towards the end of the project. The effectiveness of the hourly count tool in highlighting and solving problems was also being reduced because of the increased performance of the line, simply because of the way the tool works: target is missed, the problems that caused the target to be missed are registered. Conversely, when the line *does* hit target, nothing is registered. While everyone attested to the fact that a lot of problems *had* been solved - which is also evident from the fact that the line's performance had increased so much - the lack of registered problems obviously does not mean that there were no problems. A '*kanban* stock' had also been established between the stator and motor area which was, in fact, not a *kanban* system at all. The stator production was still being pushed by production orders, so this was just another buffer inventory stock.

5.6 Conclusion

This chapter introduced the case of the GSE lean implementation project on the MG 90/100 production line in GMH1 in Grundfos Manufacturing Hungary. The first phase of the project was initiated under difficult circumstances, the project team struggled, and the project saw little to no success. The second phase of the project was assisted by two consultants who changed the approach to the implementation, and together with the project team achieved much better results both in terms of lean implementation success and line performance improvement. After the project ended, the local team was able to sustain most of the things which were implemented during the project, but unable to progress further in with the lean effort.

CHAPTER 6

Case Analysis

6.1 Introduction

In this chapter, the case of introducing lean in the form of Grundfos Shopfloor Excellence on the MG 90/100 line in GMH1 is analyzed in detail with respect to the four propositions made in chapter 4. First, it is analyzed how management support and active leadership affected the implementation process. Second the sequence in which lean elements were introduced is analyzed, focusing on the role of operational stability in the different phases of the implementation. Third, the importance of establishing a culture for continuous improvement and problem solving is investigated. Fourth, the role and nature of initial knowledge and continuous training in a lean implementation is scutinized. Finally, additional findings and rival theories are investigated.

6.2 Proposition 1: Management Support and Active Leadership

The first proposition was:

1. Unambiguous management support from the beginning as well as active leadership throughout the implementation process is necessary for a successful lean implementation.

6.2.1 Phase 1: All Talk, No Walk

In the first phase of the GSE project on the MG 90/100 line, management support was there in name to some extent, but there was no active leadership. Part of the reason was that the initial motivation did not come from GMH's own top management, but from the corporate Grundfos group management in Denmark. Additionally, no concrete guidelines were given from the group management concerning how to go about the implementation of the lean initiative. Consequently, the response from GMH's top management was to 'obey the order' with as minimal a resource allocation as possible, making the first incantation of the GSE in GMH nothing more than one day per week allocated to one engineer. Add to that that the engineer was told after three months to downprioritize the GSE project in favor of his other responsibilities, this had the direct consequence that for what was nearly the first year after the GSE initiative had originally been started, nothing was done in GMH. In an interview, one of the managers pointed to this mistake as he reflected upon the decisions taken back then:

> *"When [the engineer] came back from Mexico in June (...) he came here, and he took one [new production introduction] project, and besides, he made also this [the GSE project]. Because, I don't know, maybe we just underestimated this [the GSE] and we said: 'Ok. Just do it - by the way."'*

In essence, management was trying to cut corners and not commit more resources than absolutely necessary. Since there were no tangible goals or requirements in the start, it was not necessary to have more than one person working on it one day per week for management to be able to fulfill the only requirement - that they were 'doing GSE'. It was not until the more tangible requirements of reduced WIP and production lead time were set by the Grundfos group management that real resources were committed.

Furthermore, when the GSE team was formed and the first phase of the GSE project started, the mindset of the management was one of obtaining 'quick fixes' rather than committing long term to lean. While the initial purpose of the GSE projects was to implement lean starting with the five main elements of GSE, this was hardly recognizeable from the project charter that was developed. The MG 90/100 line was chosen because it was the line that was in most trouble. While this can be a good choice since it increases the profile of the project, it had a negative impact here as the main purpose of the project became to fix the large amount of unresolved problems and outstanding matters pertaining to the line, rather than implement lean. The five main elements were relegated to being almost mere footnotes in a ten-page document with a problem statement not even mentioning the lean elements and containing no less than thirteen extra KPIs - many of which there was either no baseline for, and/or no established procedure for measuring. As most of the departments in GMH1 (logistics, engineering, quality and production) would be providing resources to the project in form of their employees allocated to the line's local team, every department head was virtually compensated in the form of 1-3 wishes for what long-standing problem or declining KPI he/she wanted the project to fix. Nearly every interviewed project member emphasized their dismay with this. One team member said:

> *"At that time it was also an imagination from the management that the GSE team is coming, and solve the problem. (...) we have the magic wand."*

Another team member added that he thought the general manager was very dedicated, but that he and the rest of management had had unrealistic ideas about the project - that everything could simply be fixed within 3-5 months regardless of circumstances, obstacles and scope. This was also highlighted by management's decision to cut in half the amount of resources (in terms of available time from the local team) that would be made available for the project. Taken together, the many problems to fix, the many KPIs, the short timeframe and the scarcity of resources resulted in, as one team member put it, 'the plan being too ambitious for the resources available'. According to several team members, this caused general confusion about what the intention of the project was. It was also the primary cause behind the enormous 100-item action plan that was developed in the first phase of the project:

> *"This was our mistake because... We didn't know, really, what was the expectation from management. Because they defined around 12 or 20 different project KPIs. If you want to solve twenty different KPIs, you should have a very long list [of actions] - and very long time."*

The many goals and the long list of items to solve in very little time caused a lot of frustration within the team as they felt they faced an impossible task.

> *"We had too many targets to reach, and too many ways to go, and we just did not - I think - make the prioritization. Maybe we handled everything as a first class problem. (...) One month before the end of the supposed finish date of the first phase, we realized that we didn't pay attention to the targets at all. We were just going on, trying to reach a better level, but there were no measured key points behind it. Of course we signed a charter with dozens of features and target points, but we didn't even know how to measure them (...) and we didn't know what the original status of them was."*

When the project got under way in the first phase, there was no active management leadership or support. While the plant manager did assemble the operators and the local team at the start of the project for a meeting and stated that this was an important project, nothing was since done to show that this was in fact the case. There was very little communication to the organization about what was going on, and management did not actively participate in the project in any way. As one team member puts it, the first phase of the project it felt like they were 'working behind the curtains'. The project team had a biweekly review with management, but the review really was a factual reporting of project status rather than a constructive dialogue about how to create progress. Management only came with input when a 'management decision' was directly requested. One team member describes management's role during the first phase of the project:

> *"They waited for the results. (...) we made a project charter, and they were just waiting for the results. (...) there was no support."*

During the first phase of the project, another contributing factor to the lack of active leadership was the fact there was no real production manager for the MG area. In May 2010 the previous production manager had been fired, and during the first phase of the project, the plant manager acted as temporary production manager as well, although in name only as the role of production manager was rarely prioritized over his many duties as the plant manager. The scarcity of resources also grew worse during the project, as the local team did not put the time into the project that they were supposed to do. Part of the reason for this was that the managers of the support functions were not really supportive of the lean project, and therefore had their employees in the local team prioritize daily operations and other assignments higher. One member of the GSE team even expressed that he felt unsure about whether the managers of the support functions even knew what was going on on the line. Top management, however, did not react to this and consequently, the local team started to feel that the project wasn't that important after all. As a result, the 3-man GSE team had to do most things themselves. Growing increasingly frustrated as the project went along, they requested managerial intervention and more time from the local team several times, but nothing ever came from it.

6.2.2 Phase 2: Increased Support and Visible Commitment

Both top management commitment and leadership increased during the second phase of the project when the consultancy company was hired to assist the project implementation. In one way, the large investment made to hire the consultancy firm was a direct sign of support for and commitment to the project. At the same time, the fact that a large investment had been made also significantly upped the ante and increased top management's desire to involve themselves personally in the project as large money was now on the line.

The increased management support and active leadership was visible in many ways. During the first briefing meeting with the consultants, the plant manager of GMH1 stated that everyone in the plant was supposed to treat what the consultants said as if he had said it himself. When the lack of local team commitment and time allocation was raised on a later management review meeting, the plant manager practically chastised the local team members and told them to come to him if they felt they had something more important to do than work on the GSE project. The lead production process engineer, for example, said:

> *"More resources were devoted to the project after [the consultancy company] came - it was clearly stated that this was my first priority. If my manager saw I had a problem, he tried to help me. [One of my colleagues] got a lot of my regular duties during the GSE project, because he didn't have this kind of project so he had much more free time."*

The management review meetings were changed from biweekly to weekly, and were held on the shop floor next to the visual information board rather than in a meeting room. While the form of the meetings was still largely a reporting of project status, the subsequent discussions were filled with constructive dialogue. Both the general manager and the plant manager frequently participated in the morning local team meetings, and sometimes showed up unannounced with suggestions, questions or just plain interest in what was going on. The hiring of an actual production manager for the MG area in the early phase of the project also helped a lot, as he had a lot more time available to actually participate in the project than the plant manager had had when he was the acting production manager. It is debatable whether the short term 'quick fix' mindset was still in effect in this phase. On the one hand, they did hire a consultancy focused on capability development through coaching, but on the other hand, the main KPI for the consultancy firm was increased output, and management did seem to care less about whether the improvements made to the line were lean-related or not as long as they helped achieve the goal of higher volume.

After the GSE project ended, things went 'back to normal' in terms of management support and leadership. While the jury is out on whether the short term mindset ever left, it was definately back when the project ended and the line was back to everyday operations. One member of the local team stated that after the project ended, the focus on permanently solving the line's problems was quickly abandoned in favor of straight up improving quantity. With the continuation TIP, the team had developed a plan for how to deal with the major problems on the line, but management wasn't particularly interested in that:

> *"(...) we have some open issues about GSE tasks, for example KPIs. We have to make some KPIs much better in the next half year, but the main focus from the management is the quantity (...) we didn't solve all the problems we have got until now. We cannot focus on the problems."*

The management attention had also dwindled. The plant manager still checked the visual information boards daily, but did not actively participate in promoting the lean effort on the line. While the support function managers' interest in the lean effort increased during the actual project, they no longer showed up at any of the shop floor meetings - neither the daily action meeting for the shift, nor the local team meetings. The only manager that really continued to support the process was the production manager, who was still very much involved in the lean activities on the shop floor, even if his focus was on the MG 71/80 line rather than the MG 90/100 line, as was also the case for the rest of the local team.

6.2.3 Conclusion

The analysis of the first proposition regarding management support and active leadership showed that in the case of the lean implementation in the GSE project on the MG 90/100 line, the lack of management support and commitment in the early phases of the project directly affected the initial lack of success. Management set unrealistic targets, did not provide the support and resources for the project to succeed, and did not involve themselves in the project or show leadership in any way until the decision was made to bring in the consultancy company. The increased management support in terms of visible engagement and increased resource availability in the second phase helped facilitate the process of implementing visual management and systematic problem solving methods. Thus, the case provides evidence to support the proposition.

6.3 Proposition 2: Basic Operational Stability

The second proposition was:

2. Establishing basic operational stability is a prerequisite for the implementation of the more advanced technical elements of lean.

6.3.1 Phase 1: Unstable Process, No Standards

According to several members of the project team, production at the MG 90/100 had been a very unstable process for a while prior to the GSE project. During the global financial crisis in 2009, the MG 90/100 line had been the line operating at lowest capacity, sometimes as low as 40%. After the crisis had ended, demand suddenly exceeded the line's capacity, and the line was unable to perform like it used to.

> *"In the beginning this line was very very poor. It suffered from many things - machine breakdowns and so on, lack of specification regarding manpower, many things (...)."*

There were many machine availability issues on the line. The two testers on the motor assembly line, the MG tester and the MGE tester, were both frequently out of order for several hours, and in some cases, several shifts. In the stator area, the problems were mainly related to extremely frequent minor breakdowns of the sewing machine and the inserters. There were problems with material availability as well, as production often stopped because of a lack of components on the assembly line. Either the components were in the warehouse and not on the line and the operators had to go find them, or they might have gone 'missing' (the production lines had an unfortunate habit of 'borrowing' materials from each other), or they might not be anywhere at all due to either a late supplier delivery or simply a failure on the part of the logistics department to order new materials. The line also had several manpower related issues which made the line unstable. The main reason for these issues was actually a problem with basic man management. First of all, when operators were missing, there was no established contingency plan for how to deal with such a scenario. To make matters worse, supervisors often did not know who was and was not at work until several hours into the shift. When operators came to work, they simply walked to their usual workstations and started working - there was no headcount checking. By the time the supervisor realized that a certain operator was missing, a specific station might have been non-functional since the start of the shift. Secondly, while the supervisors had a 'skill matrix' illustrating which operators had what competencies, its use was limited, it was outdated, and there was no development plan for how to get better cover for the critical positions where only one person in a given shift had the necessary skill level.

Finally, neither of these things would have made large problems if it was not for the abnormally high rate of absenteeism on the line. Long term absenteeism was high, with many operators being absent for several months at a time. The same was the case for short term absenteeism, especially in the second half of the year. The absenteeism was not only due to sickness, but also due to poor management of holidays. The company had no established rules for how many people could have holiday at the same time. Because of high demand in the start of the year, the line's managers had continuously asked operators to postpone their holidays. Consequently, it was not an infrequent sight to have 4-6 people from a 35-40 person shift on holiday on the same day during the second half of the year. Additionally, short term absenteeism due to sickness was also very high, and there was no follow-up from the supervisors or management when someone would return from short term absenteeism - they'd simple show up at some point and go back to work, no questions asked. One member of the GSE team said about the instability of the process:

> *"I think three things are necessary for a stable production: manning, machine availability, and raw material availability. All of them were missing before the GSE project. There was no preventive maintenance on the critical machines, there was no balanced manning, and there was a lot of material shortages."*

Furthermore, there was a complete lack of standards on the MG 90/100 line. There were no standards for housekeeping, no standards for how to perform the work or the cycle time of each step, no clear separation of workstations, no standards for maintaining and cleaning the machines. In the start of the second phase of the project when the consultants were trying to familiarize themselves with the line and its problems, they would often ask 'is this good condition or bad condition?' when seeing such things as a damaged fixture, a WIP-cluttered production line, a very dirty production area etc. No one was able to answer them. The point the consultants were making was that when you do not have a standard, how can you know when you have a problem? According to the GSE team, management never appreciated the sorry state that the line was in when the project was first initiated:

> *"From actual status to improved status, it's very difficult to jump. So we have to stabilize our processes, and the management has a special requirement - the management sometimes wants to go from actual status to improved status. They should understand that at first, we should go to the standard status, and after that, we can go to a higher level."*

Several members of the team suggested that these activities should have been divided into two: first standardize, then improve. The problems with lack of standards and process stability, referred to as 'silly issues', were preventing the team from implemeting the more common lean tools:

> *"We wanted to implement different lean tools, and the problem was that because of the instability of the production, we can't improve. At first we should stabilize our processes, and if they are stable, if we have stable processes, after that, in the second phase, we can improve. There was no stable production, there was no standard, and we wanted to implement the tools of improvement."*

The project team members complained that half of the activities on the long action plan were standardization issues that should have been solved by the local team in their daily work. However, because the company did not allocate enough resources to these things, the GSE project was expected to develop the standard, bring the line up to the standard level, and improve it further. Because of the short timeframe, this resulted in the team trying to do everything at once. One team member said that the problem in the first phase was not that they did not focus on resolving these issues with lack of stability and standardization - they were just lost in the mass.

> *"In the first phase, we focused on that - and 100 other things."*

Some of the team members also reflected on their previous experiences with making improvement projects in the company, including lean projects. The lack of standardization, they said, was the main reason that improvements were never sustained.

Amongst the many actions taken in the first phase was the implementation of the five main GSE elements: PM, 5S, SOP, VSM and OEE. Of these, only the PM module went according to plan. The VSM was useful for getting an overview of the line, but the actual improvements to achieve the future state never materialized. The remaining three initiatives were either never used (OEE), never fully implemented (SOP), or fell apart (5S). However, the project team believed that except for OEE, these were the right elements to start with, and that the lack of success should be attributed to the fact that they weren't able to focus on those elements.

> *"I think those elements would lead to having a good performance (...). All the five together would lead to an efficient way of performing production. (...) Those are the basics - the foundation of a good production."*

The team recognized the value of especially 5S, PM and SOPs for maintaining a stable production. The one person who did not support the choice of these elements in fact supported the very same conclusion as he argued that these things (standard operating procedures and 5S) should be there before the lean project - because they are basic elements of production.

6.3.2 Phase 2: Stabilizing the Process through Problem Solving

During the second phase of the project, the focus was to establish basic visual management and continuous problem solving. Because these problems of instability were the biggest problems preventing the line from maintaining the targeted output per day, the visual management information board and the built-in problem solving loop automatically ended up focusing on ironing out these problems and inconsistencies. Several team members directly pointed to the impact of the visual management information board as the key as it helped uncover the root causes of the problems, and systematically solving these helped stabilize the production. Together with the preventive maintenance project starting to have an effect, the focused problem solving on machine breakdowns including the use of focus boards for particularly problematic machines substantially reduced the amount of machine problems disturbing the line, both during the project and after the project ended. The problem solving loop helped put the focus on the manpower and man management issues. The daily action meeting, a 'manning overview' table on the information board, and the tracking of a KPI showing the amount of employees at work in each shift on the KPI board helped bring the manpower issues to the surface. As the facts were there for all to see, management hired more people for the struggling and vastly undermanned night shift. Rules were developed to ensure that no more than two operators would ever have holiday on the same day. A follow-up procedure was developed for employees returning from sickness.

An important element in the second phase of the project, the challenge days, directly underscore the importance of basic stability. In essence, the challenge day temporarily eliminates the problems of operational instability, and shows what the line is capable of if machines, manpower and materials are available, and if maintenance and toolsetters respond quickly to problems. On the first challenge day, the morning shift exceeded target by 19%, and on the second challenge day, by 53%. In comparison, the same shift had not even reached half the target on the day before the second challenge day, and were approximately 20% short of the target on the day after - both days because of problems with the MG tester and slow response from the test and maintenance departments. The local team was emphatic that the challenge days had been an eye-opener to everyone. Maintenace had since become quicker to respond to problems, the employees had regained confidence that they were capable of performing well, and management had gotten a better understanding of the problems and issues on the on the line after having spent an entire shift there.

For the continuation phase, part of the plan was to continue problem solving, and finally introduce the standard operating procedures and 5S. Then, the plan was to begin with the more advanced elements such as line balancing and *kanban*. As mentioned in the previous chapter, this process stagnated because of a lack of long-term improvement focus and contentment with having reached the target, and a consequent prioritization of resources elsewhere. Therefore, it was not possible to investigate whether such initiatives would have had better success in the more stable and standardized line. However, the lack of basic operational stability definately hindered the lean efforts in the first phase of the GSE project.

6.3.3 Conclusion

The case provided ample evidence to confirm the need for basic operational stability early in the process of implementing lean. The lack of operational stability in terms of machine, material and manpower availability as well as a lack of standards was shown to cause problems in the early phases of the project. The GSE team's plans for making improvements were either impossible to implement (such as the plans for implementing a *kanban* system), or gave no results as the instable process largely dictated the performance of the line. The experiments with challenge days in the second phase of the project showed the large performance gain achieveable through simply providing a stable process. The focus on solving the root causes of problems relating to both machines and manpower provided a more stable and solid foundation for the potential implementation of e.g. line balancing by the local team after the project ended. In conclusion, the findings back up the second proposition.

6.4 Proposition 3: Problem Solving Culture

The third proposition was:

3. A culture for waste reduction through continuous improvement and problem solving should be established early on in the lean implementation process.

6.4.1 Phase 1: Firefighting, Meetings and Resignation

The traditional culture in GMH1 had been one of firefighting and inaction rather than continuous improvement and problem solving. This sentiment was echoed by every single interviewee. One interviewee said that he believes most people were aware there were problems, but they didn't have time to step back, analyze the problems, find the root cause, and solve the problems. Another team member explained that the company lacked focus on long term improvement, and that firefighting had become the way of things over the past years:

> *"The main issue is that in Grundfos, we are very good at firefighting, we learned it, and we accepted that this is the way."*

Another described the culture as:

> *"Daily firefighting. 'DFF'... It's a Grundfos system... Process."*

This firefighting culture was mentioned as one of the top inhibitors of success in the first phase of the lean project. Furthermore, the middle and upper management in GMH1 had developed a habit of spending a lot of time in meetings discussing, arguing and planning, and very little time actually *doing*. One example of this is the 'operative team meeting' which was held every single day for 1.5 hours. All the members of the local team for every single line in the GMH1 plant was required to attend the meeting. According to the local team on the MG 90/100 line, these meetings were a complete waste of time:

> *"We just talked about the problems, and we did nothing."*

In general, the meetings were not very value-adding. One project team member explained that the many meetings was a part of the company culture:

> *"So, we want to design everything. Plan the plan, planning how to plan the plans..."*

The same was the case for the company's improvement projects. A lot of time would be spent on analyzing the current state, making suggestions for improvements and investments, and developing an action plan. But when it came to actual action, it was rare that anything was actually implemented, and rarer yet that what was implemented was sustained. Resoures were not dedicated to the implementation, managers did not attend the follow-up meetings, and there was no consequence when deadlines were exceeded etc. Lastly, after having performed poorly and being plagued by problems for a long period of time, the culture on the MG 90/100 line had developed into what can best be described as a resignation mindset. For example, in the beginning of the second phase of the project, the line was stopped for several hours due to a machine breakdown. The supervisors, coordinators and operators would throw up their hands in powerlesness and smile bitterly at what they considered to be a tragic yet very common and ultimately unavoidable situation. Disbelievingly, the consultants asked the supervisor why he was not furious that nothing was being done about the machine breakdown that had stopped his line for half the shift. The supervisor merely shrugged, gave a strained smile and said that that was sadly the way of things. This shows that the employees had simply come to accept the sorry state of the line and the lack of support as the standard.

In the first phase of the GSE project, changing this culture was not a priority - it was not even an item on the action plan. The items on the action plan were largely technical in nature. Because of the firefighting culture, problem solving was never started for the items on the action plan, and the meetings were not focused on action:

> *"We simply started with everything, we'd go into a room and... the problem solving was not started. It was a gossip party, you know? Everybody started to tell something - news and so on. (...) the problems were not solved."*

The team did not have knowledge about systematic problem solving methods, and were relying on random ideas. The focus was on the immediately visible problems rather than the root causes, and on technical issues rather than changing the culture and mindset of how to approach the task of improving/fixing the line.

6.4.2 Phase 2: Problem Solving, Facts and Improvement

In the second phase of the project, establishing a facts-based problem solving culture where problems were visible and dealt with in a systematic manner to improve the process was the main focus. One member of the local team felt that 'everything changed' with the approach taken by the consultancy company, and that their work became much easier when they were given specific tools for highlighting the problems (hourly count and the visual management information board) and solving them in a systematic way (PDCA, PPS and focus boards). The local team also emphasized that because the hourly count showed an estimate of how many motors had been 'lost' to a specific problem, it automatically helped prioritize the many problems the line experienced. Rather than try to solve everything at once, the team would deal with the problems 2-3 at a time, with the most important ones first, and actually solve them. This was exactly what the team had been looking for to solve the basic stability problems:

> *"(...) to achieve the standard we need practical problem solving or PDCA, and after we achieve the standard we can work on improvement kaizen, or process improvement."*

The information flow of the visual management information board and the hourly count also helped highlight more basic problems that other tools such as VSM had not uncovered, e.g. the many breakdowns and the manpower issues. The hourly count also helped the daily management of the production as supervisors and coordinators had gotten an overview of the status of the production line hour by hour. This enabled them to realize problems much faster, and to respond (or have e.g. maintenance respond) much faster.

> *"The production is more stable, and if there is a problem, it will be presented on the DAM-wall immediately. So it's very easy to follow the actual status of the production, and if there is a problem, they can start immediately - or in one day - an action or a countermeasure."*

Additionally, it became much easier to make the support functions solve problems. Before, it had been word against word. Now, the facts were on the information board for everyone to see - problems were no longer hidden, and no longer subject to discussion and subjective opinion. An extra benefit of the problem solving culture was that the instruments to facilitate it - the hourly count, the visual management information board and the daily action meetings - were all run by coordinators and operators. Giving them the responsibility of this had the effect that the employees felt a lot more involved in the project than they had been before, where there had been no involvement of the operators:

> *"Now they sign [by raising their hand]: 'I would like to make something'. In every shift. For example now, a PDCA is running in the night shift."*

The consultancy company also worked on changing the meeting room culture to one of *genchi genbutso*: they placed great emphasis on having every single meeting, even management reviews (which initially seemed preposterous to some of the project members) on the shop floor next to the line. Similarly, every time the team would begin speculating about how something might be on the line, the consultants would take the initiative and tell them to go to the line and see for themselves. The senior consultant also held a string of one-on-one meetings with the top managers which in large part were focused on changing their way of thinking about lean to a more long-term, improvement oriented one than the quick-fix mindset that had characterized the initial approach.

After the project was finished, however, it was difficult to maintain the new way of thinking. While the GSE team was convinced that problem solving should be the future of the company, the GSE team members voiced their concern that the local team (which they were now working with on the other line, MG 71/80) was not fully committed to the problem solving process, often complaining and resisting because it required them to do 'extra work'. They also felt that once the consultants were gone, management once again turned their focus on the short-term results, and were only around when things were 'burning'. However, the technical director did seem to have changed his mindset as he explained during an interview in the third phase of data collection, two months after the project ended:

> *"Lean is a culture. It's a culture of improvement. For the improvement and the culture you need to have a strong foundation. You need to have people who understand that change and improvement is important - this is their daily life, this is not a project (...)."*

> *"It's not about doing it on one line, in my opinion - it's about long term. If you want to have long term, sustainable lean thinking and, let's say, a culture where you work with improvements, you want to be better and better always, you need to have a strong culture for that."*

6.4.3 Conclusion

The analysis of the case regarding the third proposition showed the impact of developing a culture for problem solving and improvement early in the process of implementing lean. Because the focus in the first phase of the project was on the application of a specific set of tools as well as improving a large range of KPIs rather than changing the negative culture on the line, the changes rarely materialized, and even more rarely translated into performance improvements. By developing the visual management information board to highlight the actual problems on the line and automatically prioritizing these, the focus was put on the problems that were actually preventing the line from succeeding. By the use of systematic problem solving methods, the root causes of these problems were solved and the stability and performance of the line was improved, and the lean effort progressed. Thus, the proposition that a lean culture is an important first step in a lean implementation is found to be supported.

6.5 Proposition 4: Initial Knowledge & Training

The fourth proposition was:

4. For a lean implementation to succeed, a critical mass of lean knowledge, both theoretical and practical, must be present from the outset, and training which is in correspondence with the elements being implemented must be provided.

6.5.1 Phase 1: Lack of Practical Knowledge and Lean Understanding

The necessary knowledge and understanding of lean was not present in the organization to begin with - neither within the GSE team, the local team or management. Initially, the GSE team had no idea how to proceed with the implementation of lean on the line. Until the directive came from the Grundfos group to use the five main elements, they had little idea as to how to tackle the job of implementing lean on the line:

> *"It was still not totally clear who should be doing what in this process, but we knew that the implementation was important for lean. And then came the indication from*

> *Denmark that we have to implement the five main tools, and then we had a more clear picture of what we had to do."*

Some members of the GSE team had quite a bit of theoretical lean knowledge, but what was missing was the practical knowledge - how to operationalize and implement the lean elements:

> *"We realized very soon that we didn't know the whole picture. So, we knew the tools - we knew the tools exactly, detail by detail, but we didn't know how they could be presented for the whole organization."*

The team asked management for help several times - training, coaching, outside help - but it was not granted until the consultancy firm was brought on board towards the end, and the project was re-launched.

The local support team lacked lean knowledge to an even greater extent, and what was worse, lacked knowledge regarding the MG 90/100 line. The whole team was new to the line, with everyone but the planner having been in their positions for less than half a year, and the quality engineer having been hired just as the GSE project had started. A member of the GSE team explained:

> *"Even for them it was very difficult to... for example to know what is the standard. The quality engineer a lot of times was nearly crying because there was no clear standards for what was good and bad quality. So also for them it was very difficult to understand the workings of the line (...)."*

Furthermore, no one from the local team had any experience with lean, or had received any prior training in lean. Upon assuming their positions the team had gotten training in project leadership, communication and presentation skills and such, but no lean training. The local team members all expressed that they felt that both they and the operators had needed lots of training to begin with. There had been a plan for how to improve the local team's lean knowledge, but it never came into effect because of a shortage of time. The only training they did receive was brief theoretical classroom training by one of the members of the GSE team. The problem with this was expressed by one member of the local team:

> *"For instance, the lean tools. For working with the OEE - it's very simple! To understand what is OEE about, to multiply availability with the performance efficiency with the quality rate - yeah. But how to set an OEE card? How to train the operators? How to make them use it? It's much more different."*

Becaue of the lack of training, the local team did not have the necessary capabilities to implement the lean elements. Additionally, because the training had been theoretical only and because the local team was generally just told to 'do this, implement this, fix this', the team did not understand the 'why' of the things they were doing. Naturally, the local team's commitment to the process was quite low.

Finally, the management's understanding of lean was lacking. This was both the local management (the plant manager, the technical manager and the logistics manager) and the technical director who was the direct superior of the GSE team. The local management's lack of understanding of lean directly effected their skepticism towards the project, and lack of support for it. The lack of lean understanding within top management was one of the main contributing factors to the unrealistic project goals and timeframe in the first phase - as one member of the GSE team stated:

> *"My problem with this lean implementation here is that here at Grundfos, on the management level, they have no experiences. Lean knowledge and methods and project management is not well known, and... poor knowledge."*

Management's lack of understanding for lean principles, techniques and methods also made it impossible to ask them for help or advice when the team did not know what to do. They were left to their own devices and received no support because no one had the knowledge to provide support.

6.5.2 Phase 2: Practical Knowledge and Learning by Doing

In the second phase of the project, the consultancy firm brought both practical knowledge and a process of learning by doing rather than theoretical classroom training. The focus of the consultants was not to develop the solution themselves, but to coach and guide the project team (both the GSE team and the local team) through the process of developing and implementing the solutions. Thereby, the focus was on capability development through learning by doing. The consultants provided a wealth of practical knowledge about lean and how to implement it and make it work that no one in the organization had. This approach was much better says one member of the local team:

> *"They brought their examples from their former lifes and former companies, how it worked (...) and they put much more focus on developing the system - and it was training, but more coaching than training. (...) I'm an engineer - not a philosopher. This always works much better this way [learning by doing]."*

The GSE team also acknowledged that they learned a lot from the consultants regarding the practical methods, the thinking way and cultural aspects of lean:

> *"It was very helpful to see [the consultant's] method and thinking way, and we learned a lot from [the consultants]."*

The project team particularly emphasized the practical tools such as hourly count, the visual management information board, the T-card system, the challenge days, the systematic problem solving techniques etc., as very helpful for actually operationalizing the principles and improvement culture of lean. They also emphasized that the coaching method was very beneficial as it both increases understanding of why something is done the way it is and creates a sense of ownership for those involved.

While the GSE and local team learned a lot from the consultants, they still believed that they needed additional training. However, as previously mentioned, after the project ended, focus was turned from training, learning and capability development to short-term productivity improvements once again. The knowledge assessments that had been made towards the end of the project provided an excellent basis for pinpointing exactly what knowledge was missing, yet no training plan came out of it. Several members of the GSE team voiced their concern that while they believed the local team had enough knowledge and understanding of the practices implemented during the project to sustain them, they would not be able to improve and introduce more elements of lean to the line.

6.5.3 Conclusion

The analysis of the fourth proposition highlighted the initial lack of practical lean knowledge, and the lack of lean understanding in especially the local team and local and top management, as one of the things contributing to the lack of success in the first phase. The

GSE team was unable to get further than the analysis stage as they lacked tools for operationalizing the lean elements, and the local team was not committed to the project as they did not understand why they were supposed to do what they were asked to do. The consultantcy company brought the necessary practical lean knowledge to operationalize the process of implementation and take action rather than just analyze and measure. Their methods of coaching and learning by doing also helped increase the capabilities of both the GSE team and the local team, and increase the understanding of lean at all levels of the organization. To conclude, the case provided evidence to support the fourth proposition.

6.6 Additional Findings & Rival Theories

In addition to the findings regarding the four propositions, the case study provided insight regarding two issues in particular which deserve individual mention. Furthermore, in any case study, it is important to consider rival theories as explanations for why the case turned out as it did.

6.6.1 Further Findings

Throughout the case study and case analysis, there have been some recurring issues which affected the success of the lean implementation in the case, which are not part of the framework presented in chapter 4. These are:

- Resources
- KPIs and goalsetting

Resources

In the first phase of the project, the GSE team had done a lot of analytical work and come up with a large amount of actions and changes to be done on the line. However, the case showed that the lack of resources (people and time) in the first phase of the project substantially hindered the project's progress beyond analysis and recommendations and into actual action and implementation. As suggested in the analysis, this was also related to the lack of management support and active leadership as they were supposed to make the resources available, and to the lack of knowledge and training in terms of the capabilities of said resources to actually perform the job. Yet, the lack of resources played such a substantial role in the case that it must be considered as a significant element in the lean implementation in itself.

KPIs and Goalsetting

The issue of KPIs and goalsetting was also related to management support and commitment as management plays a significant role in the selection of KPIs and goals for a project. However, the case made very clear the detrimental effect that having too many, too unrealistic goals can have on a lean implementation. While this may be considered common project management and performance measurement knowledge, it is worth mention as it relates to the element in the implementation framework known as 'performance measurement and policy deployment' under the alignment of organizational supporting systems. The findings from the MG 90/100 GSE project suggest that while an actual alignment of the performance measurement system of the organization may be for the later stages of the process, it is important to consider the element of KPIs and goalsetting for the individual projects from the beginning.

6.6.2 Rival Theories

Recall that the purpose of this research is to investigate the relationship between the variables (the framework elements around which the study's four propositions are phrased) and the success of lean implementation - not the actual performance such as fx the output of the line, as it has been clearly established in the literature that lean success in turn leads to a plethore of benefits, including productivity improvements. However, as the case study does offer the success in the second phase of the lean implementation project as a reason for the productivity improvements and more stable process achieved on the MG 90/100 line, it would be prudent to consider rival theories for this as well.

Rival Theories for Lean Success

While the case has been made in the previous sections for the relationship between each of the propositions and the success (or lack thereof) of the lean implementation on the MG 90/100 line, there are other factors which likely contributed to the lack of success in the first phase and substantial success in the second phase.

Several of the GSE team members argued that part of the reason that they had not had success in the first phase of the project was that they had never really gotten around to the implementation part, because of the short timeframe. They argued that the analytical work that had been done in the first phase of the project allowed the consultants and the team to 'hit the ground running' in the second phase of the project, and achieve results. However, another of the GSE team members admitted that while they will never know if, given more time, they would have been able to achieve results with the initial approach, he doubted it. While plausible, the problem with this explanation for the success in the second phase of the project is that the analytical work done in the first phase was neither necessary nor actually used for the second phase of the project. While the VSM and the knowledge of the GSE team was helpful for the consultants to quickly get an overview of the status of the assembly line, it was not used for anything else during the second phase of the project. The VSM was not revisited until the continuation TIP was developed during the end of the second phase of the project, where a select few of the many issues were chosen as items for the continuation TIP.

Another potentially contributing factor for the lack of success in the first phase of the project was the (arguable) lack of a **capable change agent**. While the local team members believed the change management skills of the GSE team had been just as good as those of the consultants, the opinion of the GSE team members themselves was that change management capabilities was an area where the team had been lacking. The style of the GSE team's change management had been a mainly directive push-style, often ordering the local team to do this and that by this and that date. The approach of the consultancy company was the completely opposite as their focus was on coaching the team members and helping them develop the solutions together - a collaborative approach.

The collaborative style of the consultants did not limit itself to the project team, but extended to the employees on the shop floor as well, which increased the **employee involvement** in the change process. This may have also contributed to the success in the second phase. In the first phase, after the LEGO-based change involvement workshop held in the start, the operators had not been involved at all in the actual change process. The division of work had been clear: the GSE team would analyze, design and order, the local team would implement, and the operators would do. In the second phase of the project, the coordinators and several operators were involved in the lean activities. They were made responsible for data collection, for updating and maintaining the visual management information board, for analyzing the problems and finding the top issues, and were directly involved in the problem solving activities. This increased both ownership, understanding and consequently, attitude towards the changes from completely indifferent to positive and participative.

Lastly, communication about the ongoing changes had been virtually non-existant in the first phase of the project. As previously mentioned, one local team member described the first phase as 'working behind the curtains'. There was only one-way communication between top management and the project team (the team reporting status), there was no communication towards the rest of the organization which was hardly aware that the project was ongoing, and there was no communication towards the operators beyond the initial briefing meeting where they were informed that the project would be taking place. Communication between top management and the team improved somewhat in the second phase, but the real difference was in the communication towards the operators. Through the daily action meetings and the visual management information board, the operators were given daily updates on the status of the line and its issues. It was also possible to follow the status of the project as it was visualized on the information board by the project TIP.

Rival Theories for Performance Improvements

There are three main rival theories to consider that could explain the considerable performance improvements achieved in a very short timeframe. Firstly, from the start of December 2010, production of a specific type of stator referred to as the '**NEMA**' stator was temporarily halted. The stator was custom-made to specific standards employed in the USA, and these standards were up for review in 2011. This stator had a significantly longer cycle time in some specific operations. Therefore, stopping the production of NEMA stators likely had an impact on the output volume. However, the average amount of NEMA stators produced was very low. Additionally, this can only be a contributing factor to the jump in performance between November and January. Between January and March, no changes were made to the product mix.

Secondly, as mentioned in the case study, November and December 2010 were plagued by high **absenteeism** rates because holidays had been postponed to the end of the year, and because a lot of people were calling in sick. From January, absenteeism was much lower. This was certainly a contributing factor to the performance improvements. Yet, as was the case with the NEMA stators, this only helps explain the performance increase between November and January. Absenteeism did not change from January to March.

The third rival theory, however, could potentially explain the performance increase from January to March. Towards the end of February, the **second motor assembly line** which had only been used sparingly up to that point was finally officially approved by Grundfos standards and taken into full use. However, before that, the MG 90/100 line had already achieved a level of output with one assembly line which made other stations the bottleneck rather than the assembly line, namely the heating or 'baking' process (heating of the stator housing and insertion of the stator into the house) and the lacquering process (lacquering of the stator wiring). Therefore, the mere addition of a second line would not have been enough to ensure the performance improvements seen from January to March.

All three rival theories were undoubtedly contributing factors, and it is impossible to specify exactly how much of the improvement that can be attributed to these factors. It is also highly unlikely that these factors alone account for the performance improvements, especially the quality improvements, as neither of the three rival theories affect the quality KPIs of the line.

6.7 Conclusion

This chapter analyzed the case of implementing lean on the MG 90/100 line from the perspective of the four propositions formulated in chapter 4. Regarding the first proposition concerned with management support and active leadership, management's lack of support and involvement in the first phase was a contributing factor to the lack of success in this phase. Conversely, their increased commitment and visible participation helped the project to succeed in the second phase. The analysis of the second proposition regarding basic operational stability found that the lack of operational stability in the first phase had stalled the lean implementation process, and that the focus on these issues in the second phase of the project was a determinant factor for the progress the project then made. The importance of establishing a problem solving culture early in the process was also highlighted. The existing culture had been negative and passive, and nothing had been done to rectify this in the first phase of the project. The focus on creating a problem solving culture early in the second phase was a driving factor behind both the reduction of the operational stability problems as well as the progress of the lean implementation in general. Concerning the fourth proposition, it was shown that the organization had lacked practical knowledge and lean understanding in the first phase, that there had been virtually no training to change this, and that this had resulted in the inability of the organization to convert analyses and plans into action. In the second phase, the practical lean know-how and collaborative approach and training of the consultancy firm increased the level of lean understanding in the organization as well as the capabilities of the project team, which acted as an enabler to the success achieved in the second phase of the project. Thus, the analysis of the case found support for all four propositions.

Additionally, rival theories for both the success and increased performance in the second phase of the project were discussed. Regarding the success of the project in terms of lean implementation, the rival theories concerned the presence of a capable change agent, communication, employee involvement and the impact of the analytical work done in the first phase of the project. Technically, each of the four propositions themselves also prevent rival theories to each other. It is not possible to definitively determine to what extent either of these contributing factors can account for the lack of success in the first phase of the project, and increased success in the second. Yet, there is ample evidence in the case to suggest that each contributed significantly.

CHAPTER 7

Discussion

7.1 Introduction

This chapter reviews the research approach, and discusses the findings of the case study and their implications for the lean implementation framework. A slightly revised version of the framework introduced in chapter 4 is presented. The chapter further discusses the academic and practical contributions of this research, its generalizeability, its weaknesses, and concludes with suggestions for future research.

7.2 Recapitulation of Research Approach

The main purpose of this research was to investigate the different aspects of managing and planning a lean implementation. The research question guiding this research was:

> *How can the implemention of lean production be effectively planned and managed?*

Due to the lack of a comprehensive, coherent framework incorporating both the technical, organizational and change management aspects of lean implementation, the main research objectives became:

1. To develop a framework for the effective implementation of lean production which considers both technical, organizational and change management aspects.
2. To refine this framework using a case study.
3. To provide examples of how to operationalize the framework.

In order to accomplish the first research objective, a literature review of lean, change management and existing lean implementation frameworks was conducted. The gaps in the existing frameworks were identified. Based on the existing literature about lean, change management and lean implementation, a framework was developed which synthesized the existing knowledge. This framework incorporated both the technical, organizational and change management elements necessary to ensure a successful lean implementation.

To accomplish the second research objective, four propositions were developed to investigate a select few key aspects of the framework. These were:

1. Unambiguous management support from the beginning as well as active leadership throughout the implementation process is necessary for a successful lean implementation.
2. Establishing basic operational stability is a prerequisite for the implementation of the more advanced technical elements of lean.
3. A culture for waste reduction through continuous improvement and problem solving should be established early on in the lean implementation process.
4. For a lean implementation to succeed, a critical mass of lean knowledge, both theoretical and practical, must be present from the outset, and training which is in correspondence with the elements being implemented must be provided.

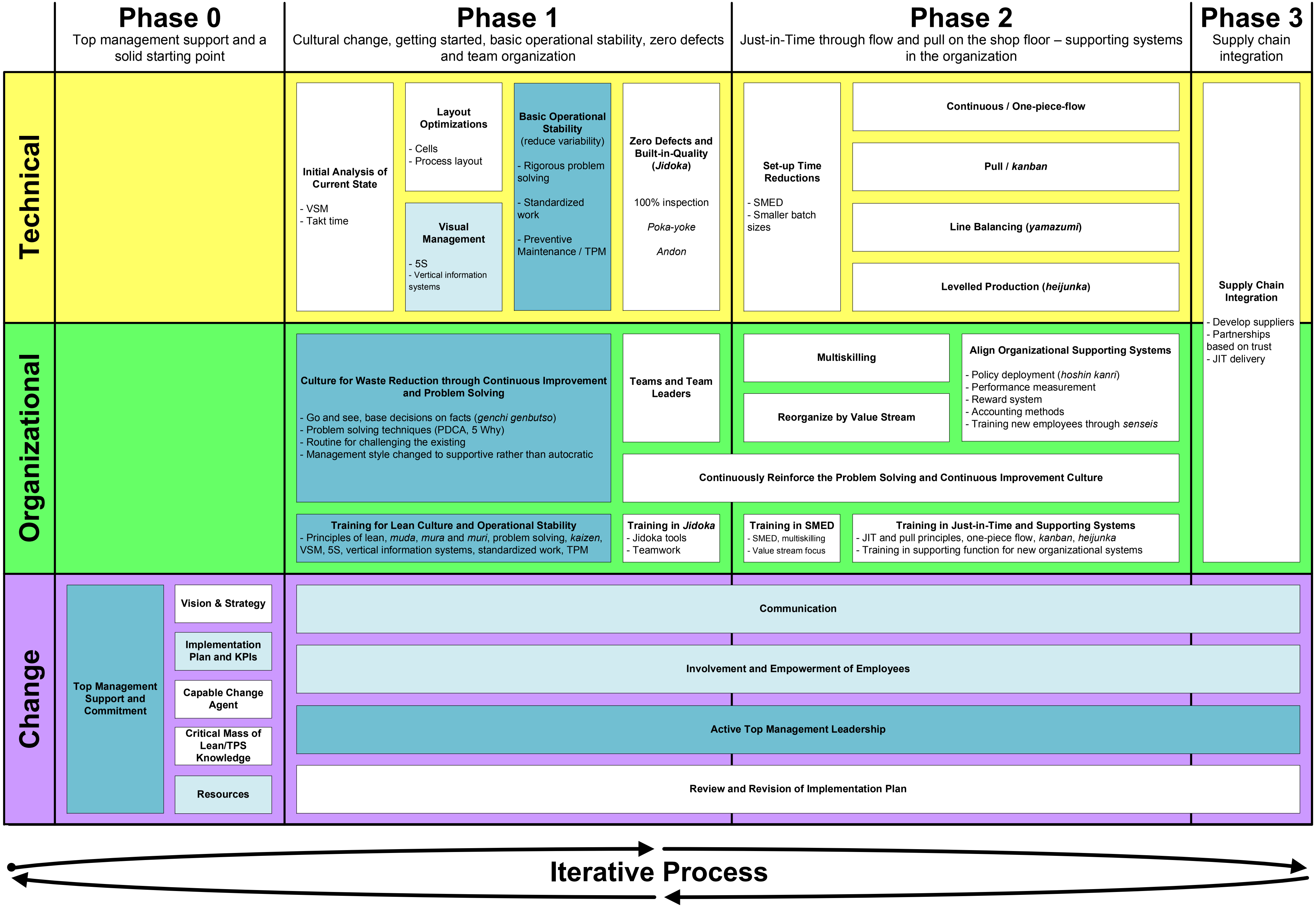
Through a case study of a project for the implementation of lean in Grundfos Manufacturing Hungary, these propositions were investigated. In this chapter, the findings from the case study analysis are discussed, and the framework presented in chapter 4 is refined in accordance with the case study findings.

The third research objective was to provide concrete examples of ways of operationalizing the framework. The case study provided several such examples. These are also discussed in this chapter.

7.3 Revision of Framework

One of the three main objectives of this research was to provide a framework for the effective implementation of lean production which considered both the technical elements, the organizational aspect, and the change management process. This framework was presented on page 55 in chapter 4. Through the formulation of four propositions, four major elements of this framework were investigated by means of a case study. Based on the findings from this study, a revised framework is presented on page 99. The framework elements investigated and confirmed are highlighted in the framework in dark blue. The case study also provided insights and confirmation regarding the importance of visual shop floor management, communication and involvement of employees. Additionally, it brought attention to two important elements that the initial framework did not include: the importance of providing sufficient resources to follow the project through, and the importance of careful consideration of goals and KPIs for the project to ensure that the project is realistic and aligned with strategic objectives. These elements are highlighted in the framework in light blue. As it would be redundant to explain the entire framework once more, please refer to chapter 4 for a full account of the phases and elements of the framework. This section is concerned with the implications of the findings from the case study for the revised framework.

The case study found evidence to support all four propositions made. As such, the revised framework is not vastly different from the original framework presented. The case study confirmed that for lean to succeed, top management must understand the philosophy and principles of lean, and support it unambiguously from the outset. If top management has a short term focus and seeks to gain easy, quick wins rather than commit to lean as the long term operations strategy of the company, then the rest of the organization will also come to



Phase 0
Top management support and a solid starting point
Phase 1
Cultural change, getting started, basic operational stability, zero defects and team organization
Phase 2
Just-in-Time through flow and pull on the shop floor – supporting systems in the organization
Phase 3
Supply chain integration
Technical
Initial Analysis of Current State
- VSM
- Takt time
Layout Optimizations
- Cells
- Process layout
Visual Management
- 5S
- Vertical information systems
Basic Operational Stability (reduce variability)
- Rigorous problem solving
- Standardized work
- Preventive Maintenance / TPM
Zero Defects and Built-in-Quality (Jidoka)
100% inspection
Poka-yoke
Andon
Set-up Time Reductions
- SMED
- Smaller batch sizes
Continuous / One-piece-flow
Pull / kanban
Line Balancing (yamazumi)
Levelled Production (heijunka)
Supply Chain Integration
- Develop suppliers
- Partnerships based on trust
- JIT delivery
Organizational
Culture for Waste Reduction through Continuous Improvement and Problem Solving
- Go and see, base decisions on facts (genchi genbutso)
- Problem solving techniques (PDCA, 5 Why)
- Routine for challenging the existing
- Management style changed to supportive rather than autocratic
Teams and Team Leaders
Multiskilling
Reorganize by Value Stream
Align Organizational Supporting Systems
- Policy deployment (hoshin kanri)
- Performance measurement
- Reward system
- Accounting methods
- Training new employees through senseis
Continuously Reinforce the Problem Solving and Continuous Improvement Culture
Training for Lean Culture and Operational Stability
- Principles of lean, muda, mura and muri, problem solving, kaizen, VSM, 5S, vertical information systems, standardized work, TPM
Training in Jidoka
- Jidoka tools
- Teamwork
Training in SMED
- SMED, multiskilling
- Value stream focus
Training in Just-in-Time and Supporting Systems
- JIT and pull principles, one-piece flow, kanban, heijunka
- Training in supporting function for new organizational systems
Change
Top Management Support and Commitment
Vision & Strategy
Implementation Plan and KPIs
Capable Change Agent
Critical Mass of Lean/TPS Knowledge
Resources
Communication
Involvement and Empowerment of Employees
Active Top Management Leadership
Review and Revision of Implementation Plan
Iterative Process

see the initiative as just another project that will soon be forgotten. Top management's support must also translate into action as they must both set KPIs and targets that correspond with lean being the strategic direction, and provide sufficient resources both in terms of time and capability to see the initiative through. Finally, the job of management does not stop with setting the scene. For the project to be prioritized and visible, top management too must prioritize participating in it and thereby visibly demonstrate the importance of the project's success. Managers, whether they like it or not, lead by example; if they do not participate to demonstrate that the project is important, then it will not be important.

The case further confirmed the need for operational stability early in the process of lean implementation. Since one of the main purposes of lean is to reduce waste, instability in operations is also the main thing that can prevent lean success; when the wasteful buffers are removed, the system is exposed and more fragile, and the effect of these instability problems will have significant consequences for performance. If one starts by removing the buffers without addressing the problems they are 'protecting' the system from, the lean initiative will quickly come to be associated with poor and erratic performance as well as a frustrating amount of suddenly very visible problems. Thus, establishing visual management, standards and basic operational stability first and then gradually removing the buffers is the better course of action.

This research also supported the proposition that creating a culture for problem solving and continuous improvement should be given attention at the very early stages of the process. The simple reason is that the capability for problem solving and the meticulous, systematic problem solving process is useful at every single stage of the lean implementation process as well as in other projects and in daily operations. The lean tools are solutions or countermeasures to specific problems. Ensuring that the organization is attacking the most important problems first, and that the root cause of these problems are addressed rather than the surface issues, ensures that the right things are done at the right time, as opposed to a blind application of various tools for the sake of the tool itself. Additionally, establishing such a culture early in the process will allow for plenty of practice in the techniques as well as reinforcement of the culture as it becomes associated with the improvements that are achieved. This will increase the odds that it does indeed become a deeply ingrained culture that will create a base for continuous improvement.

Finally, the study found that it is important that the organization understands lean and how to apply it. In GMH, there was knowledge about the basic tools and techniques, as is probably the case in most organizations. Yet, what proved to be critical was the lack of practical knowledge, the ability to transform the theoretical knowledge into action. This knowledge must be in place in the organization for the lean implementation to procede beyond the stage of diagnosis and move from the plans and spreadsheets and onto the shop floor. Additionally, because of the importance of practical knowledge, basic classroom theoretical training, while useful, is not enough in itself. It must be followed up by learning by doing under the guidance of those with the necessary practical knowledge to coach others.

7.4 Academic Contributions

This research contributes to the existing body of knowledge on lean implementation in several ways.

7.4.1 Consolidation of Several Perspectives on Lean Implementation

The existing literature offered several perspectives on what the 'key' is to a successful implementation of lean production. One strain led by authors such as Shingo (1989) and Monden (1983) emphasized the technical elements of lean production, their interrelation, and the synergy achieved from the integration of these elements into a holistic manufacturing system. According to this perspective, the key to lean success is to implement the entire system - not just the individual elements. A second strain of literature led by authors such as Spear and Bowen (1999), Lathin and Mitchell (2001), Liker (2004) and Ballé (2005) focused primarily on the organizational and cultural aspect of a lean organization. They argueed that the key is to develop a lean culture, a learning organization which strives to continuously improve by challenging the existing standards and improving through systematic problem solving. A third strain, definately the least developed, had authors such as Åhlström (1998) and Bhasin and Burcher (2006) argue for the sequence in which lean elements are implemented as being an important factor to successful lean implementation. Finally, a fourth strain considered the process of implementing lean production from the perspective of organizational change management, and authors such as Smeds (1994) and Nordin *et al.* (2008) argued that effective management of the change process is the key to a successful lean implementation. Rather than attach itself to either of these strains of literature, this study sought to consolidate the existing literature and rather than elect a 'winner', synthesize the knowledge into a framework which incorporated and accomodated for all the different views. The result of this is a framework for lean implementation which describes both the technical, organizational and change management aspects of a lean implementation, and considers the sequence in which these different elements should be regarded.

7.4.2 A Comprehensive Framework

The literature review found that there were several gaps in the existing frameworks for lean implementation. The frameworks by Smeds (1994) and Nordin *et al.* (2011) were almost exclusively focused on the change management aspect of the implementation and might as well have described the implementation of a completely different concept than lean. The framework by Shingo (1989) focused on the technical elements and their interrelatedness only, and paid virtually no heed to the organizational and change management aspects. The framework by Womack and Jones (1996), while much more comprehensive than the other three, largely neglected the technical dimension as it focused on the change management process and building a lean organization to support the lean production system. In conclusion, no framework captured all of the different perspectives on the implementation of lean production previously mentioned. This research offers a such a comprehensive framework.

7.4.3 Insights Regarding Framework Elements

The case study of the implementation of lean in Grundfos Manufacturing Hungary provided further insights into a number of the important elements in a lean implementation, and thus adds to the existing body of literature describing and investigating these elements in relation to lean implementation. The elements were management support and active leadership, basic operational stability, culture for problem solving and continuous improvement, and knowledge and training. The case study also highlighted the importance of resource availability and realistic and strategic goalsetting to the framework, two elements which had not been touched upon by the existing literature on lean implementations. While both are undoubtedly very well documented in other fields such as project management and strategy and strategic management, this research highlighted their relevance in the case of lean implementation as well.

7.4.4 Potential Extension of the Lean Toolbox

The case study also provided several examples of the usefulness of practical tools such as hourly count, the visual management information board, daily action meetings and practical problem solving - tools which have not traditionally been considered part of the 'lean toolbox'. Nonetheless, the case showed that these tools can help operationalize the process of implementing e.g. a lean culture oriented toward problem solving and increase both involvement and communication. While these tools are quite basic and practical and not so technically advanced and interesting as e.g. *kanban*, their demonstrated usefulness may warrant that these tools be considered part of the lean toolbox in the future. Indeed, they may very constitute part of the 'missing link' between application of the lean tools and achieving a truly lean organization.

7.5 Practical Contributions

This research has two main practical contributions: a framework which can be used as a guide for lean implementations, and several examples of practical tools which operationalize some of the more intangible elements of implementing lean production such as creating a problem solving culture, ensuring employee involvement, and securing active leadership from management in the process.

7.5.1 A Guiding Framework

This research offers a framework which can be useful for practitioners seeking to implement lean production. The framework highlights all the relevant elements that are necessary to consider in such an implementation, offers a description of what these elements entail, and a guideline for the sequence in which these elements should be implemented. It also emphasizes what must be done to manage the change process itself. While the framework is not to be considered a pick-and-choose toolbox, it is also not to be seen as a rigid step-by-step model. The framework offers guidelines for how to implement lean production, but every situation is different, and the change agents in charge of the implementation should base their decision on where exactly to start in the process and what to do in each step on the given situation. What is important is that each of the elements is planned for, that their interrelatedness, dependencies and synergies are taken into consideration, and that, eventually, they are all implemented. Finally, it must be emphasized that the process is iterative and that you are never 'done with 5S' or 'done with SMED' - it will be both necessary and beneficial to continuously revisit the different elements and stages of the framework as the need to do so arises.

7.5.2 Practical Tools for Operationalization

There is a wealth of literature on both theory and operationalization of many of the technical elements of lean - value stream mapping, 5S, SMED, *kanban* etc. However, many of the organizational and change management elements are quite intangible and more difficult to operationalize. The case study of Grundfos Manufacturing Hungary provided great insights as to how some of these more intangible elements of the framework can be implemented.

Operationalization of Technical Elements

The case study provided an example of how to implement visual management in practice. The visual management information board is a great tool for easy visualization of the status of the production, its current problems and issues, and the status of the actions taken to solve these issues. One of the reasons for its effectiveness is that it is serves as a completely objective fact base that no one can argue with. When the facts are in the open for all to see, the finger-pointing and bickering stops. Issues such as why the production stopped, whose fault it was, whose responsibility it was to fix the problem etc. is no longer a matter of subjective opinion, but facts.

The case also showed that establishing a problem solving culture where problems are uncovered and tackled in a systematic manner is a very effective way to achieve operational stability (in addition to preventive maintenance and standardized work). Finally, the concept of challenge days is useful for practitioners wanting to put operational stability on the company's agenda, particularly since it brings management to the shop floor to see the issues for themselves - you cannot ignore what is right in front of you.

Operationalization of Organizational Elements

The research provided several practical tools for operationalizing the implementation of a problem solving culture. Through hourly count and the visual management information board, problems were automatically brought to the surface, prioritized and visualized for everyone to see. In addition to the traditional PDCA method for tackling problems, the case showed that the practical problem solving (PPS) procedure as well as focus boards can be useful tools for systematically analyzing a problem, finding the root cause, and developing a permanent countermeasure.

The case further exemplified how effective learning by doing is when the issue is the implementation of elements of lean production, especially when the coaching/collaborative approach to developing the solutions is utilized.

Operationalization of Change Management Elements

The case study provided concrete examples of how to operationalize a number of the quite intangible change management elements. The visual management information board and the daily action meetings in each shift proved themselves to be useful vehicles for both involvement, communication and active leadership. Having the operators themselves collect the data for the KPI measurements and the problem registration, updating the information board and running the meetings increased operator involvement and ownership of the change initiative. Daily local team meetings and shiftly meetings for the operators increased the level of communication about the status of the project as well as the daily business of the line - additionally, it increased cross-shift communication. The board and the meetings also came to work as a contact point between management and the line and its local management, as it became tremendously easier for management to quickly familiarize themselves with the status and issues of the line.

As mentioned above, the concept of challenge days is an opportunity for management to show active leadership as it requires them to actively participate for an entire shift in the problem solving, measuring and registration, and inevitably provides greater insight, interest and questions from management - all of which signal active leadership. The T-card system is another tool to operationalize active leadership as it creates a routine for different levels of management to perform a series of checks on the line, and thus forces management away from the meeting rooms and offices and to the shop floor and daily operations.

Lastly, the case showed just how effective it can be to bring in outside experts to boost the level of knowledge and change management capability in the organization if a company finds itself lacking in these areas. It also emphasized the importance of not hiring outsiders who will do everything themselves, get the job done, take off, and leave the company wondering what happened. Rather, companies should hire outsiders that focus on developing the organization's capabilities to implement lean in the future.

7.6 Generalizability

Due to the choice of a case study as the research method, statistical generalization of the findings is not possible. Moreover, because of the choice of making only a single case study, traditional analytical generalization was not a possibility. However, the motivation behind conducting a single case study was that the case of implementing lean on the MG 90/100 line in Grundfos Manufacturing Hungary represents a *typical case* for a certain population of companies.

Grundfos Manufacturing Hungary is a large manufacturing company with more than 1,500 employees in a stable, mature industry. It is not a Japanese company, and thus has neither the cultural (national or organizational) predisposition for lean, nor the experience with lean manufacturing principles and methods, that many Japanese companies have. It had had some sporadic attempts at implementing elements of lean production which had largely failed. These characteristics describe a large group of companies, for which the case of Grundfos Manufacturing Hungary is considered typical. Therefore, the findings from the case study are likely generalizeable to most companies of that type.

While this limitation applies to the findings from the case, the framework itself can be applied in nearly any manufacturing operation that seeks to implement lean, for two reasons. Firstly, the framework is founded upon a solid base of existing literature and research on the topic of implementing lean production. Most elements of the framework are heavily documented (with the exception of e.g. those investigated in this research) and based on several sources of both anecdotal and empirical evidence from some of the most knowledgeable scholars and practitioners on the topic of lean and its implementation. Secondly, the framework is not to be considered a rigid step-by-step process, but rather an overview of the different elements to be considered during a lean implementation. Every case is different in starting point and context. However, the framework is a useful guide for how to proceed with the implementation of lean production.

7.7 Weaknesses and Future Research

There are several weaknesses of this research which it would be prudent to discuss. These weaknesses give rise to a number of suggestions for future research within the area of lean implementation.

7.7.1 Weaknesses of the Research

The primary weakness of this research is the inability of this study to actually test the usefulness of the framework in action. While establishing propositions based on the elements of the framework and analyzing these provided useful insights and essentially tested these parts of the framework, the better test would naturally be actually using the framework to plan and manage an entire lean implementation. Another weakness is that the framework does not provide any guidance as to how long time or how much effort should be spent in each phase, or indeed on each individual element. A third weakness of the research is that it was not possible within the scope of the study and the chosen case to investigate more than four propositions, when several more could have been formulated regarding elements introduced in later phases of the framework. Fourth, while the case can be made for the chosen case being a typical case, and while the same level of insight would not have been possible if there had been multiple cases, the external validity of the research would have benefitted from investigating additional cases. Finally, due to the lack of a method for measuring 'lean success', it was difficult to directly *prove* a causal link between the variables under study in the propositions and 'lean success', even if the evidence was clearly there to support the conclusions.

7.7.2 Recommendations for Future Research

The recommendations for future research are directly related to the weaknesses of this study. Firstly, the framework would significantly benefit from being subjected to actual testing, i.e. being used as a framework in one or preferably more large scale lean implementations as this would both test the usefulness, robustness and generalizability of the framework and allow for further refinement. Secondly, the elements of the framework which were not analyzed in the case study in this research (mainly those in phase 2 and 3 in the framework) should be investigated, with the focus on the sequence in which they should be implemented, how they can be operationalized, and the synergies and timings between the technical and organizational elements. Furthermore, while the effort in terms of time and resources as well as the duration of the different elements and phases will naturally vary greatly from case to case, the literature could benefit from more insight into how to allocate its resources in lean implementations. Finally, there is a need for an instrument to measure lean success which is not solely based on the extent to which a number of technical tools and elements are being used on the shop floor.

7.8 Conclusion

This chapter briefly recapitulated the approach taken to answer this study's research question and complete the research objectives. The implications of the findings from the case study for the lean implementation framework introduced in chapter 4 was discussed, and a slighly revised framework was presented to reflect the findings from the study. The academic and practical contributions of this research were discussed. The academic contributions are the consolidation of several perspectives on lean implementation into a single, comprehensive framework, as well the testing of elements of this framework, and the introduction of previously scarcely documented lean tools and techniques which could potentially extend the 'lean toolbox'. The practical contributions are a framework to guide practitioners through the complex process of implementing lean in their organizations, as well as the aforementioned practical tools to operationalize the implementation of intangible elements such as creating a problem solving culture. The generalizeability and weaknesses of this research was discussed, and potential directions for future research were suggested.

CHAPTER 8

Conclusion

Manufacturing is a well recognized source of competitive advantage. To achieve and maintain an advantage based on manufacturing capabilities, operations improvement is necessary. Lean is widely accepted as currently the most popular operations management concept. However, few are able to reap the promised benefits as many companies fail in their attempts to implement lean. Several authors have sought to provide frameworks to guide practitioners in the process, yet none of the existing frameworks are comprehensive enough to capture all the relevant elements and aspects of a successful lean implementation. This research has synthesized the existing perspectives on lean implementation into a single, comprehensive framework. To test the framework, a case study of a lean implementation project in Grundfos Manufacturing Hungary was conducted. This case study found evidence to confirm important elements of the framework. On the change management level, the study confirmed the need for management support and active leadership, and added the elements of availability of resources and strategic and realistic goalsetting to the framework. On the technical level, it provided empirical evidence for the need for securing basic operational stability as a first step of the implementation of the technical elements of lean. On the organizational level, the case study supported the importance of establishing a lean culture of problem solving and continuous improvement early in the process, as well as the need for the presence of practical lean knowledge in the organization and the development of the organization's lean capabilities by learning by doing. The case study further provided examples for operationalization of the framework as it showed the usefulness of a number of tools and methods used to operationalize the implementation of intangible framework elements such as creating a lean culture and securing active leadership, involvement and communication. That the four propositions investigated in the case study represent all three aspects of lean implementation; technical, organizational and change management; reinforces the main point of this research: lean is a holistic manufacturing and management system, culture and philosophy, and must be approached as such. For the effective implementation of a holistic system must be taken a holistic perspective. This research provides such a framework.

Bibliography

Allen, J.H. (2000). Make lean manufacturing work for you. *Manufacturing Engineering*, vol. 124(6), pp. 54–64.

Allen, R.K. (1997). Lean and mean: workforce 2000 in America. *Journal of Workplace Learning*, vol. 9(1), pp. 34–42.

Ashburn, A. (1977). Toyota's famous Ohno system. *American Machinist*, vol. 21(7), pp. 120–123.

Atkinson, P. (2010). 'Lean' is a cultural issue. *Management Services*, vol. 54(2), pp. 35–41.

Ballé, M. (2005). Lean attitude - Lean applications often fail to deliver the expected benefits but could the missing link for successful implementations be attitude? *Manufacturing Engineer*, vol. 84(2), pp. 14–19.

Bamford, D.R. and Forrester, P.L. (2003). Managing planned and emergent change within an operations management environment. *International Journal of Operations & Production Management*, vol. 23(5), pp. 546–564.

Bhasin, S. (2008). Lean and performance measurement. *Journal of Manufacturing Technology Management*, vol. 19(5), pp. 670–684.

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

Bidanda, B., Ariyawongrat, P., Needy, K.L., Norman, B.A., and Tharmmaphornphilas, W. (2005). Human related issues in manufacturing cell design, implementation, and operation: a review and survey. *Computers & Industrial Engineering*, vol. 48(3), pp. 507–523.

Boyer, K.K. (1996). An assessment of managerial commitment to lean production. *International Journal of Operations & Production Management*, vol. 16.

Bullock, R. and Batten, D. (1985). It's Just a Phase We're Going Through: A Review and Synthesis of OD Phase Analysis. *Group & Organization Studies*, vol. 10(4), pp. 383–412.

Burnes, B. (1996). No such thing as... a "one best way" to manage organizational change. *Management Decision*, vol. 34(10), pp. 11–18.

Cameron, E. and Green, M. (2004). *Making Sense of Change Management*. Kogan Page, Ltd., London, GB.

Carreras, M.R., Garzón, F.G., and Viadiu, F.M. (2009). Detection of the necessary characteristics in a Lean leader to achieve the success in the implementation of the Lean methodology. *In 3rd International Conference on Industrial Engineering and Industrial Management*, pp. 1595–1601.

Child, J. (1977). Organizational Design and Performance: Contingency Theory and Beyond. *Organization and Administrative Sciences*, vol. 8(2), pp. 169–183.

Convis, G. (2001). Role of Management in a Lean Manufacturing Environment.
URL: *http://www.sae.org/manufacturing/lean/column/leanjul01.htm*

Ferdows, K. and Meyer, A.D. (1990). Lasting Improvements in Manufacturing Performance: In Search of a New Theory. *Journal of Operations Management*, vol. 9(2), pp. 168–184.

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, vol. 12(2), pp. 219–245.

Fullerton, R.R. and Wempe, W.F. (2009). Lean manufacturing, non-financial performance measures, and financial performance. *International Journal of Operations & Production Management*, vol. 29(3), pp. 214–240.

Hancock, W.M. and Zayko, M.J. (1998). Lean production implementation problems. *IIE Solutions*, vol. 30(66), pp. 38–42.

Handfield, R.B. and Melnyk, S.A. (1998). The scientific theory-building process: a primer using the case of TQM. *Journal of Operations Management*, vol. 16(4), pp. 321–339.

Herron, C. and Braident, P. (2007). Defining the foundation of lean manufacturing in the context of its origins (Japan). *In IET International Conference on Agile Manufacturing (ICAM 2007)*, pp. 148–157.

Hiatt, J. and Creasey, T. (2011). The definition and history of change management.
URL: *http://www.change-management.com/tutorial-definition-history.htm*

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

Hines, P., Jones, D., and Rich, N. (1998). *Lean Logistics*. Pergamon, London, GB.

Åhlström, P. (1998). Sequences in the Implementation of Lean Production. *European Management Journal*, vol. 16(3), pp. 327–334.

Åhlström, P. and Karlsson, C. (1996). Change processes towards lean production: The role of the management accounting system. *International Journal of Operations & Production Management*, vol. 16(11), pp. 42–56.

Åhlström, P. and Karlsson, C. (2000). Sequences of manufacturing improvement initiatives - the case of delayering. *International Journal of Operations & Production Management*, vol. 20(11), pp. 1259–1277.

Holweg, M. (2007). The genealogy of lean production. *Journal of Operations Management*, vol. 25(2), pp. 420–437.

Huntzinger, J. (2006). Why Standard Work is Not Standard: Training Within Industry Provides an Answer. *Target*, vol. 22(4), pp. 7–13.

Im, J.H. and Lee, S.M. (1989). Implementation of Just-in-time Systems in US Manufacturing Firms. *International Journal of Operations & Production Management*, vol. 9(1), pp. 5–14.

Joyce, D.P. (2011). 14 Principles, 5 Principles, 5 Pillars, Which do you use?
URL: *http://leanandkanban.wordpress.com/2011/03/23/14-principles-5-principles-5-pillars-which-do-you-use/*

Jørgensen, F., Matthiesen, R., Nielsen, J., and Johansen, J. (2007). Lean Maturity, Lean Sustainability. *In* J. Olhager and F. Persson (Editors), *IFIP International Federation for Information Processing, Volume 246, Advances in Production Management Systems*, pp. 371–378. Springer, Boston, MA.

Karlsson, C. and Åhlström, P. (1995). Change processes towards lean production: the role of the remuneration system. *International Journal of Operations & Production Management*, vol. 15(1), pp. 80–99.

Karlsson, C. and Åhlström, P. (1996). Assessing changes towards lean production. *International Journal of Operations & Production Management*, vol. 16(2), pp. 24–41.

Kotter, J.P. (1995). Leading Change - Why Transformation Efforts Fail. *Harvard Business Review*, vol. 73(2), pp. 59–67.

Krafcik, J.F. (1988). Triumph of the Lean Production System. *Sloan Management Review*, vol. 30(1), pp. 41–52.

Lathin, D. and Mitchell, R. (2001). Learning from mistakes. *Quality Progress*, vol. 34(6), pp. 39–45.

Leonard-Barton, D. (1992). Core capabilities and core rigidities: a paradox in managing new product development. *Strategic Management Journal*, vol. 13(S1), pp. 111–125.

Lewin, K. (1951). *Field Theory in Social Science*. Harper and Row, New York, NY.

Lewis, M.A. (2010). Lean production and sustainable competitive advantage. *International Journal of Operations & Production Management*, vol. 20(8), pp. 959–978.

Liker, J.K. (2004). *The Toyota Way - 14 Management Principles from the World's Greatest Manufacturer*. McGraw-Hill, New York, NY.

Liker, J.K. and Rother, M. (2011). Why Lean Programs Fail.
URL: *http://www.lean.org/newsletters/02_02_11_newsletter.html*

Mackelprang, A.W. and Nair, A. (2010). Relationship between just-in-time manufacturing practices and performance: A meta-analytic investigation. *Journal of Operations Management*, vol. 28(4), pp. 283–302.

March, J.G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, vol. 2(1), pp. 71–87.

Marchwinski, C. (2006). Build Your "House" of Production on a Stable Foundation.
URL: *http://www.lean.org/common/display/?o=799*

Maskell, B. (2000). Lean accounting for lean manufacturers. *Manufacturing Engineering*, vol. 125(6), pp. 2–5.

McLachlin, R. (1997). Management initiatives and just-in-time manufacturing. *Journal of Operations Management*, vol. 15(4), pp. 271–292.

Monden, Y. (1981a). Adaptable kanban systems helps Toyota maintain just-in-time production. *Industrial Engineering*, vol. 13(5), pp. 29–46.

Monden, Y. (1981b). How Toyota shortened supply lot production time, waiting time and conveyance time. *Industrial Engineering*, vol. 13(9), pp. 22–30.

Monden, Y. (1981c). Smoothed production lets Toyota adapt to demand changes and reduce inventory. *Industrial Engineering*, vol. 13(8), pp. 42–51.

Monden, Y. (1981d). What makes the Toyota production system really tick? *Industrial Engineering*, vol. 13(1), pp. 36–46.

Monden, Y. (1983). *The Toyota Production System*. Productivity Press, Portland, OR.

Nicholas, J.M. (1998). *Competitive Manufacturing Management*. Irwin/McGraw-Hill, New York, NY.

Nordin, N., Deros, B.M., and Wahab, D.A. (2008). Change management issues in lean manufacturing: literature analysis. *In Engineering Postgraduate Conference (EPC) 2008*, pp. 1–13.

Nordin, N., Deros, B.M., Wahab, D.A., and Rahman, M.N.A. (2011). A framework for managing change in lean manufacturing implementation. *In 2nd International Conference on Industrial Engineering and Operations Management (IEOM 2011)*, pp. 858–864.

Ohno, T. (1988). *The Toyota Production System: Beyond Large-Scale Production*. Productivity Press, Portland, OR.

Olexa, R. (2002). Manufacturing lite with lean. *Forming and Fabricating*, vol. 9(9), pp. L8, L12–L16.

Pavnaskar, S., Gershenson, J., and Jambekar, A. (2003). Classification scheme for lean manufacturing tools. *International Journal of Productoin Research*, vol. 41(13), pp. 3075–3090.

Philips, E. (2002). Pros and cons of lean manufacturing. *Forming and Fabricating*, vol. 9(10), pp. 33–41.

Piatkowski, M. (2004). Training Recommendations for Implementing Lean.
URL: *http://www.lean.org/common/display/?o=45*

Pilkington, A. and Fitzgerald, R. (2006). Operations management themes, concepts and relationships: a forward restrospective of IJOPM. *International Journal of Operations & Production Management*, vol. 26(11), pp. 1255–1275.

Pullin, J. (2002). In pursuit of excellence. *Professional Engineering*, vol. 15(13), pp. 38–45.

Ross, A. and Francis, D. (2003). Lean is not enough. *Manufacturing Engineer*, vol. 82(4), pp. 14–17.

Rother, M. and Harris, R. (2001). *Creating Continuous Flow*. The Lean Enterprise Institute, Brookline, MA.

Rother, M. and Shook, J. (1998). *Learning to See*. The Lean Enterprise Institute, Brookline, MA.

Scherrer-Rathje, M., Boyle, T.A., and Deflorin, P. (2009). Lean, take two! Reflections from the second attempt at lean implementation. *Business Horizons*, vol. 52(1), pp. 79–88.

Shah, R. and Ward, P.T. (2003). Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management*, vol. 21(2), pp. 129–149.

Shah, R. and Ward, P.T. (2007). Defining and developing measures of lean production. *Journal of Operations Management*, vol. 25(4), pp. 785–805.

Shingo, S. (1988). *Non-Stock Production: The Shingo System for Continuous Improvement*. Productivity Press, Cambridge, MA.

Shingo, S. (1989). *A Study of the Toyota Production System from an Industrial Engineering Viewpoint*. Productivity Press, Cambridge, MA.

Smalley, A. (2006). Basic Stability is Basic to Lean Manufacturing Success.
URL: *http://www.lean.org/common/display/?o=934*

Smeds, R. (1994). Managing Change towards Lean Enterprises. *International Journal of Operations & Production Management*, vol. 14(3), pp. 66–82.

Sohal, A.S. (1996). Developing a lean production organization: an Australian case study. *International Journal of Operations & Production Management*, vol. 16(2), pp. 91–102.

Sohal, A.S. and Egglestone, A. (1994). Lean Production: Experience among Australian Organizations. *International Journal of Operations & Production Management*, vol. 14(11), pp. 35–51.

Spear, S. and Bowen, H.K. (1999). Decoding the DNA of the Toyota Production System. *Harvard Business Review*, vol. 77(5), pp. 96–106.

Sprague, L.G. (2007). Evolution of the field of operations management. *Journal of Operations Management*, vol. 25(2), pp. 219–238.

Stamm, D.J. (2003). Plan for lean success. *Industrial Engineer*, vol. 35(3), p. 24.

Stamm, D.J. (2004). Kinda, sorta lean. *Industrial Engineer*, vol. 36(2), p. 22.

Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R., and Samson, D. (2002). Effective case research in operations management: a process perspective. *Journal of Operations Management*, vol. 20(5), pp. 419–433.

Sugimori, Y., Kusunoki, K., Cho, F., and Uchikawa, S. (1977). Toyota Production System and Kanban System: materialization of just-in-time and respect-for-human system. *International Journal of Production Research*, vol. 17(3), pp. 193–206.

Taylor, A. and Taylor, M. (2009). Operations management research: contemporary themes, trends and potential future directions. *International Journal of Operations and Production Management*, vol. 29(12), pp. 1316–1340.

Todnem, R. (2005). Organisational Change Management: A Critical Review. *Journal of Change Management*, vol. 5(4), pp. 369–380.

Toni, A.D. and Tonchia, S. (1996). Lean organization, management by process and performance measurement. *International Journal of Operations Production Management*, vol. 16(2), pp. 221–236.

Tracey, M.W. and Flinchbaugh, J. (2006). HR's Role in the Lean Organizational Journey. *WorldatWork Journal*, vol. 15(4), pp. 49–58.

Whelan-Berry, K.S. and Somerville, K.A. (2010). Linking Change Drivers and the Organizational Change Process: A Review and Synthesis. *Journal of Change Management*, vol. 10(2), pp. 175–193.

Womack, J. and Jones, D.T. (1996). *Lean Thinking: Banish Waste and Create Wealth for Your Corporation*. Simon & Schuster, New York, NY.

Womack, J.P. (2010). Mura, Muri, Muda?
URL: *http://www.lean.org/common/display/?JimsEmailId=63*

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

Worley, J.M. and Doolen, T. (2006). The role of communication and management support in a lean manufacturing implementation. *Management Decision*, vol. 44.

Yin, R.K. (2009). *Case Study Research: Design and Methods*. SAGE Publications, Inc., Thousand Oaks, CA.

Summary

Manufacturing is a well recognized source of competitive advantage. To achieve and maintain an advantage based on manufacturing capabilities, operations improvement is necessary. Lean is widely accepted as currently the most popular operations management concept. However, few are able to reap the promised benefits as many companies fail in their attempts to implement lean. The purpose of this research was to investigate how the implementation of lean production can be effectively planned and managed. Several authors have sought to provide frameworks to guide practitioners in the process, yet none of the existing frameworks were comprehensive enough to capture all the relevant elements and aspects of a successful lean implementation. Therefore, the main objectives of this research became to develop such a comprehensive framework, refine it based on a case study of Grundfos Manufacturing Hungary, and provide examples of how to operationalize it. The research delimits itself to lean implementations within manufacturing operations, in a single company.

To construct the framework, a literature review was carried out which reviewed the existing literature on lean and its elements, change management, and the existing lean implementation frameworks. There were three main gaps in the literature. First, the fact that none of the existing frameworks seemed to build on each other as each of them addressed different aspects of lean implementation, with no framework considering all the relevant aspects. Second, there were important elements of lean which were not incorporated in any of the existing frameworks. Third, the sequence in which the elements of lean should be implemented was not well researched. To address these gaps, the constituent elements of lean implementation were summarized, and the sequence in which the technical, organizational and change management elements should be addressed was discussed. From this, a comprehensive framework for lean implementation was developed. It was beyond the scope of the research to test the framework in action, so instead, four propositions were formulated to investigate the need for (1) management support and active leadership, (2) establishing basic operational stability first, (3) creating a culture for problem solving and continuous improvement early, and (4) having a critical amount of lean knowledge prior to the implementation, and providing sufficient lean training during the process.

To test these four propositions, a case study of a lean implementation project in Grundfos Manufacturing was conducted. Evidence was found to support all four propositions. Furthermore, two additional elements were added to the framework: the importance of availability of resources for implementation, and realistic and strategic goalsetting for the

change initiative and projects. The impact of these findings on the initial framework was discussed, and a revised framework was created and presented.

The academic contributions of this research are the consolidation of several perspectives on lean implementation into a single, comprehensive framework, as well the testing of elements of this framework, and the introduction of previously scarcely documented lean tools and techniques which could potentially extend the 'lean toolbox'. The practical contributions are a framework to guide practitioners through the complex process of implementing lean in their organizations, as well as the aforementioned practical tools to operationalize the implementation of intangible elements such as creating a problem solving culture.

APPENDIX A

Questionnaire 1: Interviews with Project Team Members

Story of the project (phase one)

- What were the planned actions?
- Were they carried out? How, when and by whom?
- What other actions were done that were not planned?
- What ations were planned but were not carried out?
- What difficulties did you experience with the design and implementation of the project elements?
- How did this impact the success of the implementation?
- Why did the consultancy company become involved?

Management and leadership

- What do you think about management's role in this project?
- Have they supported the project and backed you up?
- Have management shown leadership?
- Have management actively participated in the process?
- Did you feel like you had a mandate and legitimacy from management?

Strategy and objectives

- Do you think that the project target was clear to everyone from the beginning?
- Do you think the involved people had a common understanding of direction?
- What was the approach to goalsetting from management?
- Is there a consistent focus on improvement in GMH, or is the focus related to what projects are currently running?

Change management

- Was change management an issue given attention from the outset?
- Who was the change agent?
- Was there a burning platform?
- How was the project managed?
- What characterized the availability of resources?
- Were employees involved in the project?

Organizational situation

- Were the stakeholders involved and committed?
- What are the drawbacks/benefits of the way the organization is structured to carry out a project like this?
- Did the organizational culture impact the project?
- What kind of lean training was given?
- What level of lean knowledge was available in the organization from the outset?

Post-project phase

- What will be the procedure for following up on the MG 90/100 situation?
- What are you thoughts about the continuation TIP and the local teams chances for success?
- Do you think the results will be sustained?
- What - in your opinion - were the top 3 inhbitors of a successful sustainable implementation of lean in GMH1?
- What - in your opinion - were the top 3 enablers of a successful sustainable implementation of lean in GMH1?

APPENDIX B

Questionnaire 2: Interviews with Project Team Members and Local Team

With all questions applicable, please consider before the project re-launch with the consultancy company in November 2011, and after the project re-launch.

Proposition 1: Management Support and Active Leadership

- Where did the motivation for the GSE project come from?
- Where did the initiative for the GSE come from?
- Did GMH management back the project?
- Was there an implementation strategy for the GSE projects?
- How was the GSE project initially launched?
- Who was supposed to be the change agent? Did this person have the necessary skills?
- Was the relevant lean knowledge available in the organization?
- What was the status of the GSE initiative in GMH before the consultants?
- Were the necessary resources made available for the project to succeed?
- How would you describe the large amount of performance measures related to the MG 90/100 line and the GSE project at the outset? Did this impact the success? How?
- What was done to create a 'crisis', i.e. prompt a willingness to change? Did it work?
- What was the level of 'change readiness' amongst the operators / support functions? What was done to change this?
- Did top management take an active, visible leadership role on the shop floor in the promotion of GSE before the consultants? After?

Proposition 2: Basic Operational Stability

- What do you think about the initial '5 main elements' of GSE, and the fact that it was decided from Denmark which tools were to be implemented?
- How would you assess the operational stability of the MG 90/100 line prior to the consultants' arrival in terms of man (absenteeism and skill level), machine (breakdowns), method (standardized work), material (quality and availability of raw materials)?
- What was the impact of the basic stability problems on the GSE project?
- What was the impact of the lack of standardized work on the GSE project?
- What was the impact of the lack of visual management on the GSE project?
- Do you think the issues in these areas prevented you from advancing as planned with the more advanced elements such as kanban and one-piece-flow in the initial project?
- How was basic operational stability and basic shop floor visual management changed with the consultants? What was the effect?
- What attention was given to the reduction of defects/quality problems early on in the project? What about after the consultants came?
- If you were to start the GSE projects over from scratch, which five tools would you have started with? Why?

Proposition 3: Problem Solving Culture

- Was there a focus on changing the culture in the GSE project? What about after the consultants came?
- The motto of the GSE is 'Go see - Go ask - Go do.' Was this being practiced as a culture in GMH?
- Did the organizational or national culture have any impact on the change process?
- How would you describe the culture on MG 90/100 before the consultants came? After?
- How would you describe the culture in GMH in general before the consultants came? After?
- What do you think about the problem visualization and solving loop introduced by the consultants?
- What was the role / style of management on all levels before the consultants came? Now?
- What is your opinion of the CI/problem solving culture that the consultants promoted? What has been the effect?

Proposition 4: Knowledge and Training

- What was the extent of the GSE team's knowledge regarding lean prior to the project? Was any training given before the consultants? After? What training?
- What was the extent of the local team's knowledge regarding lean prior to the project? Was any training given before the consultants? After? What training?
- What was the extent of the operator's knowledge regarding lean prior to the project? Was any training given before the consultants? After? What training?
- What were the consequences of the lack of training (on all three levels)?
- What effect did the training have (on all three levels)?
- Is the local team properly equipped knowledge-wise to handle the continuation of lean on the line?

Misc.

- Were the successes of the GSE celebrated?
- Were the operators involved in GSE activities before the consultants came? After?
- Were the operator's given some responsibility/autonomy to effect the success of the GSE project before the consultants came? After?
- How would you characterize the communication from management/GSE to the rest of the organization (especially MG 90/100) before the consultants came? After?
- Was there a conscious effort to tackle barriers to change? Were there any barriers to change? How were they tackled, and by who?
- How was the project management / review process handled before the consultants came? How effective was it? What about after?
- Was the necessary resources available (funds, manpower/time, knowledge) to complete the GSE objectives before the consultants came? After?

APPENDIX C

Questionnaire 3: Interview with Technical Director

Proposition 1: Management Support and Active Leadership

- Who made the decision that there should be a GSE?
- Who was the driving force behind the implementation of the GSE?
- What was the initial approach to GSE in GMH?
- Was there an implementation strategy for the GSE projects?
- Who was supposed to be the change agent? Did this person have the necessary skills?
- What was the status of the GSE initiative in GMH before the consultants came?
- How do you see your role as management in the GSE project(s)? Before/after the consultants?
- Were the necessary resources made available for the project to succeed?
- How would you describe the amount of performance measures related to the MG 90/100 line and the GSE project at the outset? Did this impact the success? How?
- Did you consider the creation of a 'crisis/burning platform' to motivate change, or was this already there?

Proposition 4: Knowledge and Training

- Was the relevant lean knowledge available in the organization?
- Was the level of lean knowledge in the GSE/Local/Operators/Management sufficient in the start?
- What was done to bring this up to par - who was given training and in what?
- Now that the consultants aregone from the 90/100, is the local team properly equipped knowledge-wise to handle the continuation of lean on the line?

Misc.

- You had quite a few talks with the consultants during the second phase - what were those about?
- How was the communication concerning the GSE activities to the rest of the organization, especially the operators on the 90/100? After consultants?
- Was there a conscious effort to tackle barriers to change? Were there any barriers to change? How were they tackled?
- How was the project management / review process handled before the consultants came? What about after?
- Was there continuous attention to the availability of resources (time from local team/-support, funds) for the GSE team to fulfill the objectives?
- Did the organizational or national culture have any impact on the change process?

APPENDIX D

Contents of Electronic Appendix on CD-ROM

. The folder structure of the electronic case study database is as follows.

- Documents
  - Information Board Scans
    - Scans of documents from the information board (Nov-Dec-Jan)
    - Scans of documents from the information board upon return visit (April 2011)
  - Electronic Documents
    - Various electronic documents (pdf, ppt, xls, avi)
- Interviews
  - First Round of Interviews
    - Audio files (m4a, mov)
    - Summary of each interview (doc)
  - Second Round of Interviews
    - Audio files (m4a, mov)
    - Summary of each interview (doc)
- Field Notes
  - Transcript of researches field notebook (doc)
- Electronic version of thesis (pdf)
- Note on confidentiality (txt)