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A Lean Transformation Journey

A Case Study of the Lean Implementation Process at a Medium-Sized Manufacturing Plant

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Quality and Operations Management

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The master thesis has been carried out at Gunnebo Entrance Control S.p.A. in Lavis, Italy, in collaboration with the division of Supply and Operations Management at Chalmers. Throughout the thesis, we have experienced and truly lived a Lean transformation which has offered us insights that we argue are impossible to be taught in a classroom or by reading a book.

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'Sa dirte? Grazie entant'

Martin & Johan

Lavis, 2019

Abstract

The fierce market competition has forced organizations to constantly improve in order to keep up with their competitors and increasing customer demands. Lean manufacturing is a popular improvement strategy for companies to embrace, as it aims to increase the customer value through the removal of wastes in production. However, embracing a Lean philosophy is far from easy, and an insufficient understanding of the Lean concepts and practices is a main cause of the failure rates of 80%.

This study aims to investigate how Lean manufacturing can be implemented into a medium-sized manufacturing plant and the decisive success factors, to define a suitable approach for others who seeks to become Lean. Moreover, the research aims to identify the challenges that arose during a Lean implementation at Gunnebo Entrance Control S.p.A., and the process of solving them.

The results and conclusions of this research are based on an extensive literature review of 65 publications, and a 5-month case study with daily interviews and 500 hours of observations at the shop-floor. To achieve the purpose, the authors have been involved in a Lean transformation project at Gunnebo Entrance Control S.p.A., a manufacturing plant in Lavis, Italy.

The findings demonstrate that Gunnebo was successful in their Lean implementation which is based on improvements validated through increased capacity and improved space utilization, in combination with qualitative assessments from interviews and observations. The challenges faced at Gunnebo were closely connected to change management, which stresses the importance of Lean implementation projects not only possessing appropriate Lean expertise, but also expertise in managing an extensive organizational change. Furthermore, a holistic framework for a successful Lean implementation is presented to assist companies in Lean transformations. The framework suggests lower maturity Lean practices at an early stage to provide short-term success to overcome resistance, and higher maturity Lean practices once a robust Lean foundation has been set. Lastly, following the framework will result in different Lean practices for every company and it cannot be emphasized enough that a Lean transformation, like any other extensive organizational change, has to be adapted to the specific context in order to be successful.

Keywords: *Lean, Lean Implementations, Lean Management, Lean Manufacturing, Lean Production, Lean Philosophy, Change Management, Employee Resistance, Organizational Change.*

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List of Abbreviations

Abbreviation	Meaning
5S	Sort, Set in order, Shine, Standardize, Sustain
AEOF	Italian certification of security
BP	Refers to SpeedStile BP, a product by Gunnebo (product category A)
CRP	Capacity Requirement Planning
DFMA	Design For Manufacturing and Assembly
EBITA	Earnings before interest, taxes, and amortization
EMEA	Europe, Middle East & Africa
ERP	Enterprise Resource Planning
FLH	Refers to SpeedStile FL, a product by Gunnebo (product category A)
FLS	Refers to SpeedStile FLs, a product by Gunnebo (product category A)
FP	Refers to SpeedStile FP, a product by Gunnebo (product category A)
GOS	Gunnebo Operating System
GOST	Set of technical standards maintained by the Euro-Asian Council
GS	Refers to GlasStile S (product category G)
HR	Human Resources
ISO	International Organization for Standardization
JIT	Just-in-Time
KPI	Key Performance Indicator
MPS	Master Production Scheduling
MRP	Material Requirement Planning
NVA1	Non-Value activities which are necessary for the process
NVA2	Non-Value activities which are unnecessary and should be eliminated
PDCA	Plan-Do-Check-Act
PFEP	Plan For Every Part
POS	Refers to Point of Sale (product category D)
SEK	Swedish Krona (currency)
SMED	Single-Minute Exchange of Dies
The Golden Line	Refers to an ideal production line following the Lean principles
TOM	Refers to SlimStile BA Lite, BA & EV and TriStile RO (product category B)
TPS	Toyota Production System
VA	Value-adding activities
WIP	Work-in-Progress
VOC	Voice of the Customer
VSBS	Value Stream Box Score

1. Introduction

The following chapter presents a brief background to the subject and the purpose of the study. Additionally, the problem analysis and research questions are defined, followed by the delimitations of the study and the target group for the thesis. Lastly, this chapter is concluded with an outline of the report structure with short descriptions for each section.

1.1 Background

The current intensely competitive market environment requires companies to continuously improve in order to satisfy increasing customer demands. The survival of a company relies on improving quality while reducing costs, which requires embracing changes in the organization. These changes can vary from structural organizational transformations to product-specific innovations (Sim & Rogers, 2009; Huong, 2014).

The Lean philosophy arose from the Japanese automotive industry with the intention to reduce waste. Successful Lean adaptations also enable continuous quality enhancement while reducing costs. In addition, it can lead to improved utilization of capital, increased organizational agility and shortened lead times. Evidently, there are several benefits with Lean and the principles are claimed to be applicable in all industries. For practitioners, Lean manufacturing is one of, if not the primary approach for systematic improvement of productivity. Despite being proved beneficial in many organizations, most implementation programs of Lean often fails, with failure rates pointing towards 80% (Pearce, Pons & Neitzert, 2018). This has also been proven repeatedly in other literature (Stamm, 2004; Baker, 2002; Atkinson, 2010; Sim & Rogers, 2009), demonstrating a failure rate of greater than 90 % for organizations based in the UK.

The implementation process of Lean has historically been perceived as a sequential application of tools, often conducted by consultants. The respect for human resources is in theory identified to be equally important as the methods of waste elimination, but it is not always emphasized in practice. However, there is increasing attention towards the risks of Lean transformations and the change management aspects. In fact, the consideration of human factors is now seen as vital for a successful and sustainable Lean implementation, and several change management models have as a result been developed (Pearce et al., 2018). Nonetheless, the change management aspects cannot be emphasized enough, and resistance to change can bring management into disagreement due to subtle but deeply rooted attitudes towards change. Even in cases where top management is fully committed to quality and resource allocation in education and training, these struggles are still significant (Sim & Rogers, 2009). Consequently, the Lean implementation process is affected by many different factors and managing them are fundamental in order to achieve a sustainable change.

Gunnebo Entrance Control S.p.A. is currently going through a transformation to significantly change their operations process at their assembly plant in Lavis, Italy. The change includes changes in assembly to kitted one-piece flow process, supplier development to improve automated part delivery and development of ERP, MRP, CRP and associated processes. Gunnebo defined a Lean transformation project in September 2018, called the Golden Line, which revolves around creating a perfect value stream focusing on one product family and improving all the related processes in the Lean way. Once the total solution is in place, the company sought to refine the Golden Line processes, ensuring that any issues are resolved and that the new processes meet the KPIs. The long-term goal is to include all product families in the Lean philosophy, with the aim of becoming a pioneer in the market and a role model for the Entrance Control branch.

1.2 Purpose

The purpose of this inquiry is to investigate how Lean manufacturing can be implemented into a medium-sized manufacturing plant, and study the processes and tools that are used from project initiation to a continuously improving organization. Additionally, the report aims to identify challenges that arise during the Lean implementation at Gunnebo Entrance Control S.p.A., and the process of solving them. Lastly, the study seeks to identify the decisive success factors of a Lean transformation and define a suitable approach that can assist practitioners in their Lean implementation.

1.3 Problem Analysis and Research Questions

The concept of Lean is continuously evolving which has resulted in confusion and disagreement regarding what is considered to be Lean, an issue which has been observed both academically and in practice (Hines, Holweg & Rich, 2004). Even if there have been attempts to develop quantitative measures to evaluate a level of "Leanness" of an organization, it often results in fuzzy ratings that will be affected by subjectivity (Zanjirchi, Tooranlo & Nejad, 2010; Wan & Chen, 2008). In addition, these leanness measures become further ineffective if input data is incorrect or difficult to collect (Yadav, Nepal, Rahaman & Lal, 2017). Moreover, several authors claim that the underlying reason for Lean implementation failures derive from insufficient understanding of Lean concepts and practices (Yadav, Nepal, Goel, Jain & Mohanty, 2010). Liker (2004) further stress that it is common that organizations consider Lean as a toolbox where specific tools are utilized to solve internal problems. However, this incorrect approach towards a Lean transformation often hampers the results, and failure rates of 80% for Lean implementations describe the current situation (Pearce et al., 2018). Hence, the first research question aims to investigate existing literature in order to answer:

- *Which are the success factors for overcoming the critical challenges that arise during a Lean implementation?*

Additionally, Lean implementation projects significantly differ between companies, thus increasing the complexity for practitioners (Bortolotti, Boscari & Danese, 2015). The consideration of human factors is now seen as vital for a successful and sustainable Lean implementation, and several change management models have as a result been developed (Pearce et al., 2018). While the first research question is of a theoretic nature, the second and third research question will be answered based on the case company Gunnebo Entrance Control S.p.A. The second research question aims to investigate the change management at Gunnebo Entrance Control S.p.A. during the Lean transformation, and in correlation with theory, analyze if an effective implementation framework is possible to develop. Hence, the second research question is:

- *How was the change managed by Gunnebo Entrance Control S.p.A. and what would be a suitable approach for a Lean transformation?*

Previous studies have found that roughly 70 % of change processes fail primarily due to ineffective planning and employee resistance during the implementation phase (Beer & Nohria, 2000). Similar trends are seen towards Lean implementations, with the majority of organizations struggling with their transformations. The third research question aims to identify the challenges during the Lean transformation at Gunnebo Entrance Control S.p.A. Thus, our third and final research question is:

- *What are the challenges faced at Gunnebo Entrance Control S.p.A. during a Lean implementation?*

1.4 Delimitations

This project will solely study the production plant in Lavis, Italy, and no other branches of the organization or external stakeholders, as visualized in figure 1. The included arrows within the highlighted area, represent the interactions and interfaces that the production plant has with suppliers and customers. For instance, the research will cover changes in their approach towards suppliers and customers due to the implementation of Lean. Additionally, support functions such as IT, Product Development and R&D will be excluded as these are located in the UK and not strictly involved in the Lean implementation in Lavis.

Figure 1, Illustration of the project scope

1.5 Target Group

The target audience for this thesis can essentially be divided into three different groups: Gunnebo, academicians, and practitioners of Lean.

This thesis will provide value for Gunnebo as documentation and analysis of their internal change, with insights on improvement areas. Further, this report can assist in the sharing of knowledge with other production plants within Entrance Control that seeks to follow.

For academicians, this thesis aims to provide additional evidence to support or question current theories regarding Lean implementations and their correlation to change management.

For practitioners, this thesis provides an example of how a Lean implementation can be conducted and a suggested approach of how the change can be managed. Additionally, the thesis will provide valuable insights on challenges that have been observed during the Lean implementation at Gunnebo.

1.6 Report Outline

Table 1 presents the structure of the thesis, with a summary of each chapter.

1. Introduction *Pages: 1 - 5*	The first chapter provides a brief introduction to the topic and the company. Additionally, the reader is presented with the purpose of the study and problem analysis which is concluded with three defined research questions. Lastly, this chapter specifies the delimitations and intended target group for the written report.
2. Theoretical framework *Pages: 6 - 29*	The second chapter provides the reader with relevant theories and concepts for fulfilling the purpose of this study. The two main subjects examined are Lean Management and Change Management.
3. Methodology *Pages: 30 - 34*	The third chapter describes the decided approach for this research. The utilized methods are described in detail and motivated for. In addition, the quality of the report is problematized and discussed. Lastly, the ethical issues of the study are considered and how these can be managed.

4. Empirical data *Pages: 35 - 65*	The fourth chapter presents an introduction to the case company and their products. Following is a description of the Lean transformation ranging from 2016 until May 2019. In addition, the company's intended future state to further enhance the Lean culture is described. Lastly, the chapter is concluded with a presentation of the challenges that arose during the transformation.
5. Analysis *Pages: 66 - 82*	The fifth chapter connects the observed Lean transformation to the theoretical framework which is then analyzed to answer the three research questions.
6. Discussion *Pages: 83 - 86*	The sixth chapter discusses the results and the quality of the study.
7. Conclusions & Managerial implications *Pages: 87-88*	The seventh chapter provides conclusions to the research questions, which is concluded with a list of managerial implications.
8. Future Research *Pages: 88*	The eighth chapter highlights new possible research areas that have been identified during this study.
9. References *Pages: 89-94*	The report is concluded with all of the references, which are categorized and presented in an alphabetical order.
Appendices *Pages: 95-101*	The final part of the thesis report has the intention to provide the reader with supplementary information through appendices. The following appendices can be found for this report: Key Constructs for Successful Lean improvement, Interview Template, a Value Stream Map for the past and future state and an A3-form.

Table 1, Demonstration of the report outline of the thesis

2. Theoretical Framework

The implementation process of Lean has historically been perceived as a sequential application of tools, often conducted by consultants. The respect for human resources is in theory identified to be equally important as the methods of waste elimination, which is not always emphasized in practice. However, the consideration of human factors is now seen as vital for a successful and sustainable Lean implementation, and several change management models have as a result been developed (Pearce et al., 2018). Consequently, the following chapter aims to describe the related theoretical basis of Lean manufacturing and the management of change implementations.

2.1 Lean Management

The continuously increasing market competition has forced manufacturing firms to constantly develop their effectivity and flexibility in order to address challenges due to globalization and ever-increasing customer demands (Yadav et al., 2017; Sim & Rogers, 2009; Huong, 2014). Yadav et al. (2010) stress that previous emphasis on mass production and efficiency models characterized by Taylor and Ford is no longer compatible with the current changing business environments. In contrary, the existing business climate requires more flexible production systems and enhanced value propositions. Organizations are therefore in need of implementing new strategies, methods, techniques, and philosophies in order to be competitive and sustainable (Yasin, Alavi, Kunt, & Zimmerer, 2004). Through the implementation of best practices, it is possible to decrease costs and lead times, while improving quality (Singh & Ahuja, 2012). For instance, Lean manufacturing and its tools have had a worldwide impact on manufacturing firms which aim to maximize customer benefits through the elimination of wastage (Randhawa & Ahuja, 2018).

The Lean philosophy originates from the shop-floors of Japanese manufacturers as a result of the competitive domestic environment and the scarcity of resources following World War II. In particular, Toyota Motor Corporation developed innovative operations management methodologies such as Just-in-Time (JIT), Kanban pull production, automated mistake proofing, and enhance employee problem-solving abilities. The primary focus of this approach was to eliminate waste which led to the well-known "Seven wastes of Toyota". This approach represented an alternative to the mass-production ideal of the west, which consisted of large batch sizes, dedicated assets and high amount of tied up capital (Hines et al., 2004). The difference between these two ideals is the type of efficiency that is sought. The traditional, mass-production ideal is designed to maximize resource efficiency, while the concept of Lean is instead designed to enhance flow efficiency (Modig & Åhlström, 2012).

Womack and Jones (1996) stress five key steps towards Lean: Definition of value from the perspective of the end customer, identification of the entire value stream, making the remaining value-creating steps, designing and providing what the customer wants only when the customer wants it, and the persuasion of perfection. However, the concept of Lean is continuously evolving which has resulted in confusion and disagreement regarding what is considered to be Lean, an

issue which has been observed both academically and in practice (Hines et al., 2004). Several authors agree that Lean is a complex system of a combination of hard practices (e.g. Kanban, 5S, Just-in-Time) and soft practices (e.g. customer involvement and organizational culture) (Bortolotti et al., 2015). However, it is common for organizations to view Lean as a toolbox where specific tools and methods can be utilized to address certain internal problems (Liker, 2004). With an incorrect approach towards its implementation, it is almost impossible to reap its many proven benefits, which underline the demonstrated 80% failure rate of Lean implementations (Pearce et al., 2018).

2.2 Characteristics of Lean

The existing knowledge of Lean is diffuse and diverse in its nature, and it is therefore difficult for researchers and practitioners to concretize the subject. Implementation of Lean has been conducted in companies across all industries and even if benefits are gained initially, the majority still fail to sustain the continuous improvement efforts (Yadav et al., 2017). Yadav et al. (2010) argue that most companies accomplish to implement techniques and tools for early benefits, but that their ineffectiveness in achieving consistent and sustainable improvement hampered the long-term success. Liker (2004) stress that Toyota's operational excellence is based in part on tools and methods, but that the Lean system provides approaches for people to continuously improve their work. According to the author, adopting these techniques is just the beginning of a Lean implementation, and that the culture behind Lean is critical in order to successfully transform a business. Liker (2004) states that culture characterizes the people who bring the system to life by working, communicating, resolving issues, and growing together. However, gaining a complete understanding of Lean principles and concept is complex and it is not possible to follow a step-by-step method that most companies searches for (Yadav et al., 2010).

2.2.1 The four P's of Lean & the 14 Toyota Way Principles

Liker attempts to explain the underlying philosophy and principles that are practiced at Toyota manufacturing plants all over the world. Based on his 20 years of research within Toyota, Liker presents four categories (the four "P's") which characterizes his 14 principles of Lean, organized into four categories: Philosophy, Process, People/Partners, and Problem Solving. Figure 2 demonstrates the 4P-model, which is followed by a thorough description of Liker's 14 principles divided into the four P's.

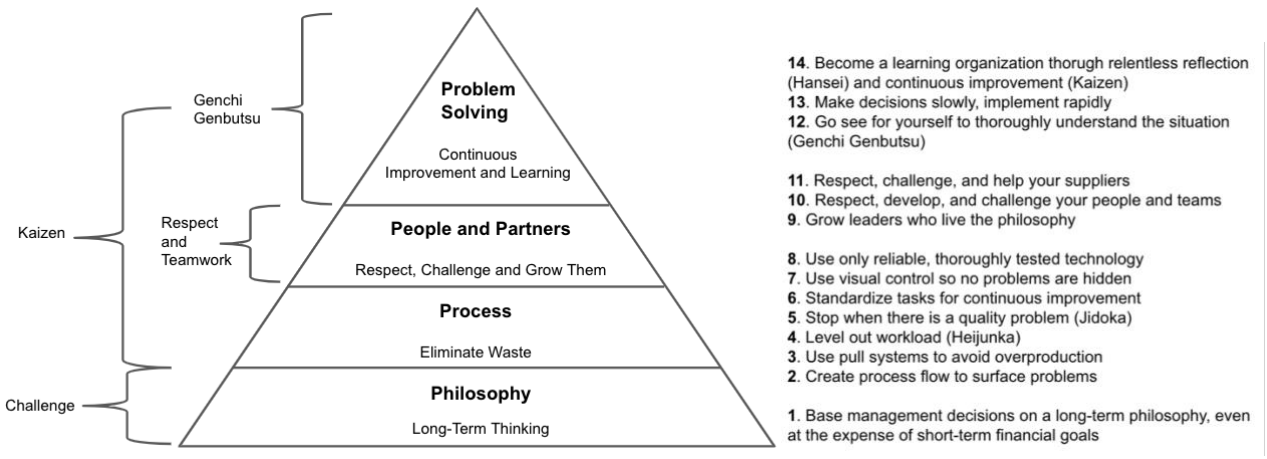

Figure 2, Representation of Liker's 4P-model

Category I: Long-Term Philosophy

The foundation of the 4P-model is Philosophy. Contrary to the typical mentality where short-term, quarterly performance is central, long-term sustainable performance is instead prioritized. The level of Philosophy is essentially the extent to which management base their decisions with a long-term philosophy in mind, even if it may result in a short-term loss (Liker, 2004).

Principle 1. *Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.*
The first principle regards the long-term philosophy which stresses the need for a shared purpose that dictates over short-term decision making. It requires a strong and deeply embedded culture throughout the organization with a long-term, customer-focused mindset. This principle is claimed to be the foundation for all the other principles. Additionally, every function should always have the focus on creating value for the customer, society, and economy, in order to create value for themselves (Liker, 2004).

Category II: The Right Process Will Produce the Right Results

The second level or category presents the Toyota way on processes. This level focuses on common Lean tools and practices such as Kanban, 5S, and Heijunka. Lean is often mistakenly assumed to only cover the implementation of these methods and tools, where the organizations have not understood the real meaning of Lean. This often results in the other levels of the 4P-model being misunderstood or simply ignored (Liker, 2004).

Principle 2. *Create continuous process flow to bring the problems to the surface.*
The second principle concerns the flow efficiency and strives to achieve a continuous flow with high value-adding operations, to eliminate any work in process projects. Another area the principle covers is to create a flow in which material and information travel quickly and linking processes and people to surface problems immediately. Furthermore, to truly have a continuous improvement

culture and successfully develop people, it is crucial to make the flow visible throughout the organization (Liker, 2004).

Principle 3. *Use "pull" systems to avoid overproduction.*
The third principle covers an essential part of Lean which is pull production flow. Pull production means that the downline customer initiates the information- and material flow. This, in turn, means that the customer is provided with the right quality, at the right time, and in the right amount. The material replenishment initiated from the customer is the basic principle of another Lean concept, Just-in-Time. Additionally, this principle minimizes the work in process and inventory as restocking is frequent in small amounts that are defined by the customer orders (Liker, 2004).

Principle 4. *Level out the workload (Heijunka).*
The fourth principle concerns eliminating unevenness in production in the form of overburden to people and equipment,. This is often overlooked by organizations trying to implement Lean even though it is just as important as eliminating waste. By evening out the production, it is possible to avoid the often time-consuming stop/start approach typically used in batch production (Liker, 2004).

Principle 5*. Build a culture of stopping to fix problems, to get quality right the first time.*
The fifth principle regards creating a quality culture which is a central aspect in Lean. The main driver of the value proposition in Lean should be what the customer considers as quality. A quality centred culture can be created by designing a system that stops the production when quality issues are detected which is supported by visual alarms that alert team leaders when abnormalities are identified. To support this approach, it is key to create support processes to quickly solve issues and implement countermeasures. Although adopting a culture of stopping production to get the quality right the first time might hamper production initially, it enhances productivity in the long run (Liker, 2004).

Principle 6*. Standardized tasks are the foundation for continuous improvement and employee empowerment.*
The sixth principle stresses the importance of using standardization as a foundation from which one can improve in an iterative process. It is crucial to use stable, repeatable methods to achieve high predictability and steady output. Additionally, by documenting the performance of a process, it is possible to identify and standardize today's best practice (Liker, 2004).

Principle 7*. Use visual control so no problems are hidden.*
The seventh principle of Lean regards the different visual support systems of Lean. These visual indicators strive to provide simple, instantaneous updates regarding the performance considering the set standards. Additionally, the principle aims to design visual systems where the work is conducted to support the pull flow. (Liker, 2004).

Principle 8. *Use only reliable, thoroughly tested technology that serves your people and processes.*
The eight principle suggests that technology should support and never replace people. New technology is often unreliable and should therefore always be tested prior to adoption. Additionally, technologies that disturb stability, predictability, reliability or conflicts with culture needs to be discarded or modified. Despite this, new technologies should be encouraged as creative solutions and should be implemented quickly after testing if proven beneficial for the flow (Liker, 2004).

Category III: Add Value to the Organization by Developing Your People and Partners

The third category focuses on the human aspects and the importance of leaders and employee empowerment. Key principles consider respecting, developing and challenging both internal and external stakeholders to make the people and the supply chain grow (Liker, 2004).

Principle 9. *Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.*
The ninth principle stresses the importance of growing leaders from within who understands the work, culture, and people of the organization. Furthermore, the leaders' function is not only to manage but also to inspire others of the company's Lean philosophy (Liker, 2004).

Principle 10. *Develop exceptional people and teams who follow your company's philosophy.*
The tenth principle considers the development of people and teams to support a strong and stable culture of shared values and beliefs. This is enabled through continuous training of individuals and teams and reinforcement of cultural beliefs. Additionally, by using cross-functional teams and developing multi-functional individuals improves quality, productivity, and enhances production flow. Teamwork has to be learned and it should be an ongoing effort to teach employees to work together (Liker, 2004).

Principle 11. *Respect your extended network of partners and suppliers by challenging them and helping them improve.*
The eleventh principle considers the importance of having strong relations with suppliers, customers, and other partners. External stakeholders are a major part of the supply chain, and they should be treated with respect and seen as an extension of the focal firm. By challenging and assisting them to develop through close cooperation shows that they are valued (Liker, 2004).

Category IV: Continuously Solving Root Problems Drives Organizational Learning

The fourth and final level focuses on how to become a learning organization. Continuous improvement methods are fundamental here, but it also addresses how to approach decision making and the importance of basing decisions on facts (Liker, 2004).

***Principle 12**. Go and see for yourself to thoroughly understand the situation (genchi genbutsu)*
The twelfth principle emphasize making the decisions based on data that is personally collected and verified at the source. Decisions regarding problems are often made off-site based on data that someone else collected, which increases the possibility of misinterpretations and suboptimal conclusions. Rather than theorizing on other individuals' observations, one should go to the source to think and speak on personally verified data. This is especially important for senior management and executives to create a more superficial understanding of the current situation (Liker, 2004).

***Principle 13**. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly.*
The thirteenth principle argues that it is important to keep an open mind and slowly process all possibilities. A definite path should only be chosen thorough consideration and contemplation. This can be conducted through Nemawashi which is the process of discussing issues and solutions with all involved stakeholders to broaden the perspective and get additional alternatives. However, once the most promising direction is chosen, actions must be quick and decisions should be rapidly implemented (Liker, 2004).

***Principle 14**. Become a learning organization through relentless reflection (hansei) and continuous improvement (Kaizen).*
The fourteenth and final principle considers the benefits of becoming a learning organization. Once stable processes have been established, one should perform Hansei, which is the process of conducting root cause analysis of inefficiencies and implementing preventative measures to avoid recurrence. This process should be done at key milestones to identify all mistakes and learn from them. Additionally, as new wastes are exposed, continuous improvement activities, such as Kaizen events, can be performed to eliminate it. Furthermore, learning is possible through rigid documentation and standardization of the best practices, that are continuously improved through an iterative process such as PDCA (Liker, 2004).

2.2.2. 7+1 Wastes of Lean

The implementation of Lean will result in the elimination or reduction of waste in the processes of an organization. Most commonly highlighted are the original seven wastes developed by Taiichi Ohno ("muda" in Japanese) and the additional waste of "unused employee creativity" which later got emphasized, thus the 7+1 wastes (Liker, 2004). Bergman and Klefsjö (2010) describe the eight wastes as:

- *Overproduction*.
  Overproduction regards the waste of producing without any customer orders, which leads to waste due to overstaffing, storage, excess inventory, and transportation costs.

- *Waiting*.
  The time used for waiting hampers the ordinary work from progressing. The waiting time, for employees, components or customers, is not value adding. If time is not managed properly it will cause disturbances in the one-piece flow which further affects the production time negatively.

- *Unnecessary transportation or conveyance.*
  If the transportation of materials, parts and finished goods are not considered carefully it will create unnecessary transportation back and forth from storage. This is costly and also require additional resources such as time and manpower, without adding any value to the product offering.

- *Over-processing or incorrect processing.*
  Unneeded or inefficient processes that does not add value for the customers is waste. In addition, the over- or incorrect processing implies unnecessary motions and can cause defects.

- *Excess inventory.*
  Excessive storage of raw materials, WIP, and finished goods creates wastes connected to damaged goods and delayed deliveries. A significant amount of tied up capital is not preferable as the company will be more vulnerable to problems connected to the items in inventory. Additionally, excess inventory can hide problems that only reveals if inventories are reduced.

- *Unnecessary movement.*
  Waste can be found in unnecessary or excessive movements such as walking or searching for components. This is a time-consuming process which does not add any value to the customer.

- *Defects.*
  The production of defects is considered as a major waste as it not only affects the production costs and time, but also requires rework. These costs add up the more time the defect remains undetected and it should therefore be managed through preventative actions rather than inspections.

- *Unused employee creativity*.
  Unused creativity or engagement of employees creates waste as a result in loss of human potential. This in turn causes loss of skills, ideas, improvements, and learning opportunities.

2.2.3 Tools and Practices in Lean Management

The key principles of Lean are often illustrated in the house of Lean (see figure 3). Similar to a house, the Lean house must be built properly in order to stand. Companies striving towards being Lean must ensure a steady and strong foundation, which is enabled through standardization. Adding the walls will further optimize the processes that are in place, which will assist in improving efficiency and quality, while eliminating waste (Bergman & Klefsjö, 2010).

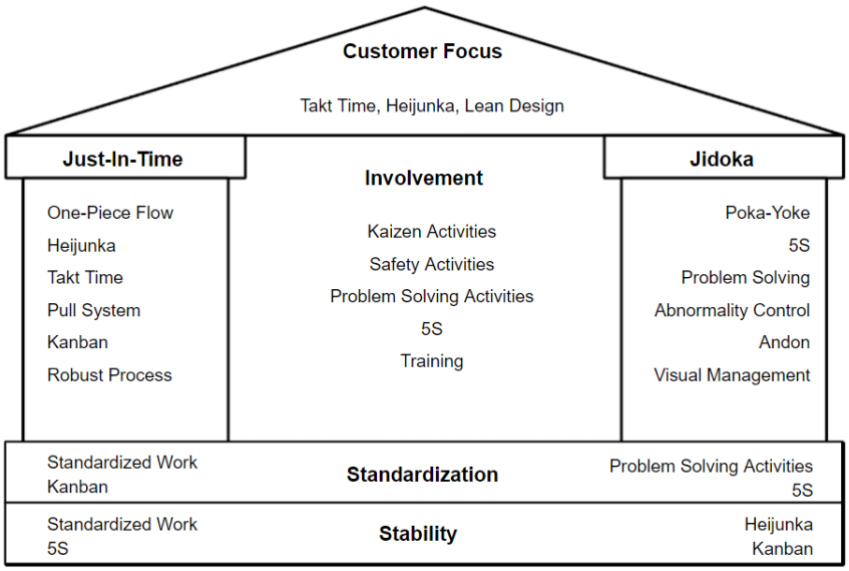

Figure 3, Representation of House of Lean

Toyota have defined three expected outcomes from Lean, firstly the customers should be provided with products of the highest quality, at the lowest possible cost, with the shortest possible lead times, with on-time delivery by engaging the whole value chain ranging from project initiation to delivery of finished product. Secondly, employees should be provided with job satisfaction and security by establishing an effective work environment. Lastly, the organization should have increased their flexibility and thereof quickly be able to adapt to changing market demands (Bicheno & Holweg, 2000).

There is, however, not a definite approach to follow and the walls of the Lean house will therefore be made from different Lean tools and strategies depending on the specific company. Yadav et al. (2017) claim that set-up time reduction, Kanban, line balancing, design of experiments, statistical methods, value stream mapping, and A3 form are among the most common and vital tools towards achieving an effective Lean implementation. Evidently, there are a significant number of tools and concepts that could be considered during a Lean transformation. Described below are the two pillars Jidoka and Just-In-Time, and the most commonly adopted hard practices, which are on different levels of abstraction.

5S

The 5S methodology (see figure 4) is considered to be the primary Lean tool for an effective and successful Lean transformation. It is a Lean thinking tool with the purpose to identify value and to eliminate the non-value adding processes (Folinas & Ngosa, 2013). Kumar, Sudhahar, Dickson, Senthil and Devadasan (2007) claim that it sets the base for the successful foundation of other quality tools. The 5S constitutes of the five principles Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize) and Shitsuke (Sustain), which cover a systematic approach towards the fulfillment of Lean in Organizations (Pheng, 2001; Ho, 1999a, 1999b; Osada, 1991). An additional sixth S "safety" has evolved and is sometimes added to promote the reduction of work injuries (Gapp, Fisher & Kobayashi, 2008).

Figure 4, The steps of the 5S (Wikipedia, 2013)

The 5S technique is also considered to be a philosophy which influences general thoughts regarding workplace management and how the employees approach their work, which set up for significant improvements of the work setting (Randhawa & Ahuja, 2018). Several authors emphasize the criticalities of management commitment, employee involvement and education for successful implementation of 5S in an organization (Randhawa & Ahuja, 2018; Islam & Mustapha, 2008; Kaluarachchi, 2009; Fotopoulus & Psomas, 2010).

Andon

Andon refers to a visual feedback system that can be used at shop-floor to indicate the production status. The main purpose is to create immediate attention to occurring problems in order to address them instantly. Originally at Toyota, a rope located above the line (Andon Cord) would be pulled when an operator detected a problem. However, it now takes various forms, such as pushing a button or through automation as it is implemented in most new software. Once an issue has been solved, the work is continued and the incident is logged as a continuous improvement activity (Bhasin, 2015).

Heijunka

Heijunka, as shown in figure 5, refers to a form of production scheduling that limits the production into significantly smaller batches by sequencing product variants within the same process. In other words, it is a way to balance and mix the production sequence to level the load on the production system. In practice, a Heijunka box is

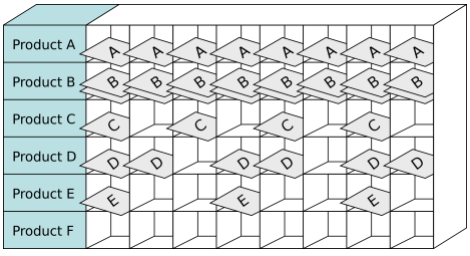

Figure 5, Demonstration of a Heijunka box (Wikipedia, 2012)

utilized to adopt the Heijunka principles, which enables a visual control of a smoothed production schedule (Bhasin, 2015).

The method is often used in combination with SMED to reduce the setup time which allows for small quantity of products to be produced without critical setup costs or lost capacity. The effects of Heijunka can be seen in reduction of lead times and inventory, as each product is manufactured more frequently in conjunction with smaller batches (Bhasin, 2015).

Jidoka

Jidoka is a philosophy of automating the identification of quality issues for individual products. When an error, or abnormality occurs, the production is interrupted and until a root cause analysis has found and addressed the issue. A Jidoka system can be implemented by designing the equipment to fully, or partially, automate the manufacturing process to automatically stop when a quality issue is detected. Having Jidoka at shop-floor enables workers to frequently monitor several lines and quality issues can be detected immediately, which reduces both labor costs and improves quality in a continuous matter (Bhasin, 2015).

Just-In-Time-Production

The Just-in-Time or JIT philosophy is a key aspect in Lean, which refers to the mindset of only delivering what is requested, in the right quantity and at the right time. In Lean, JIT is considered a core component as it seeks to minimize inventory and enhance the production and information flow. Adopting JIT implies pull production based on customer demand instead of the Western traditional push production based on projected demand. JIT enables reduction of downtime, space requirements and costs associated with inventory. Succeeding with the concept relies on a numerous of other Lean practices, such as Heijunka, Kanban, continuous flow and takt time (Bhasin, 2015).

Kaizen

The word Kaizen can be translated to “continuous improvement”. The Kaizen process is an improvement activity at low cost, that involves both managers and workers. Contrary to major innovation initiatives, improvements under Kaizen are incremental and less extensive. Despite this, the improvements gained from Kaizen events still provides significant results over time. The benefit of Kaizen is that it ensures continuous progress that serves for the long-term, through low-cost approaches and employee engagement. Hence, Kaizen is a lower risk approach where changes can always be reverted without major investments. The Kaizen philosophy, mindsets and methodologies are present in organizations worldwide, and the most successful implementers of strategies such as six sigma, JIT, TQM are customer-focused, Gemba-oriented, and Kaizen-driven (Imai, 2012).

Kanban & Pull

The word Kanban can be translated to "signboard" which has become interchangeable with demand scheduling. In a Kanban system, the operators produce according to actual consumption rather than forecast, making it a pull-production. For a system to truly be considered Kanban, it must only produce products to replenish consumed ones, and only initiate production when given a customer order (Gross & McInnis, 2003).

The implementation of Kanban scheduling replaces the traditional daily or weekly production schedule with visual signals and predetermined decision rules (i.e. Kanban cards) which enable the production operators to manage the scheduling of the line. In addition, the utilization of visual signals assists in determining what, how many and when to produce specific products. By utilizing Kanban, it is possible to reduce the work in process (WIP) and costs associated with inventory. Additionally, it can be used to surface impediments of the flow and opportunities for continuous improvement. It has therefore become key in the JIT pillar for Toyota's Lean philosophy. A well-planned Kanban allows managers and supervisors to see the schedule status of the line by the use of visual indicators (Gross & McInnis, 2003).

A specialized form of Kanban is the 2-bin system. It is an inventory replenishment strategy which consist of two bins, with the first being the "working bin" and the second being the "replenishment bin". The strategy is carried out by first emptying the "working bin" and then replenishing it with the "replenishment bin". The emptied bin is thereafter requested to be replenished and later acts as the replenishment bin. The new working bin contain enough quantities to satisfy the customer demand during the lead time plus safety stock, thus securing that sufficient material is always accessible (Bhasin, 2015)

Mizusumashi

A Mizusumashi is a role within Lean that is responsible for defining paths and routines of material management, according to Kanban and Just-In-Time (Ichikawa, 2009). By employing a Mizusumashi, it is possible to concentrate the transport Muda and remove the non-value adding tasks, such as replenishment of components or kitting, which enables the production lines to solely focus on the assembly tasks. The intention with Mizusumashi is to concentrate the problems into one function and find ways to improve by mastering them.

In a Mizusumashi system, the Mizusumashi moves between assembly lines and storages for regular replenishment of components (Nomura & Takakuwa, 2006). The logic flow of the Mizusumashi and their responsibilities is visualized in figure 6. In figure 7, an example of a Mizusumashi route is presented.

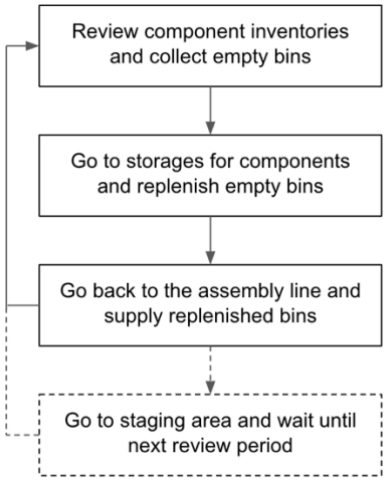

Figure 6, Logic flow of Mizusumashi

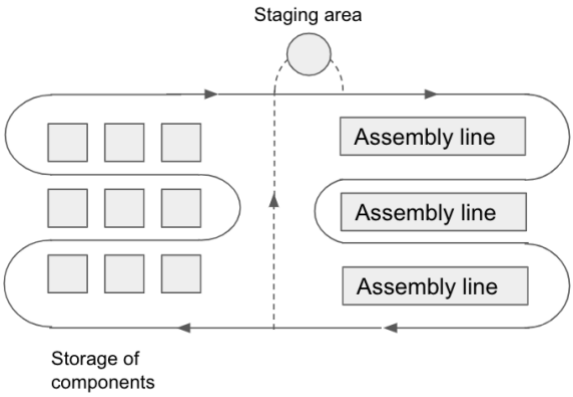

Figure 7, Example of Mizusumashi route

One-Piece Flow

In accordance to the Lean philosophy, a one-piece flow is essential. Organizations that produce in batches will experience production unevenness, which often leads to an increase in buffer sizes in order to facilitate high machine utilization. Achieving one-piece-flow entails having pieces flowing separately, throughout the production process. Although it might be difficult to fully embrace a one-piece flow, having it as a goal, and thereby continuously reduce batch sizes will surface problems to solve and assist in the elimination of waste (Gornicki, 2014).

Poka-Yoke

Poka-Yoke is a quality assurance approach which is often described as error proofed design or built-in quality in a process, product, or service. It ensures detection and prevention of errors in a process by obstructing incorrect actions. The approach is vital towards the elimination of waste as it has the ultimate goal of zero defects. For example, Poka-Yoke can be used through sizing the screws to only fit in the intended location, thereby making any mistakes impossible. As previously mentioned, a preventative approach to defects is highly preferred over a corrective action, hence making this approach valued in Lean (Bhasin, 2015; Hopp & Spearman, 2011).

Problem Solving Methodologies

There are many different problem-solving activities that can be utilized in a Lean organization, with the most famous being PDCA, A3 form, or 8D. However, these approaches are generally based on the same principles with a systematic and iterative problem-solving approach, with the main goal of creating continuous improvements (Bhasin, 2015).

For instance, Plan-Do-Check-Act (PDCA) is a scientific approach for improvement activities and consists of four phases, as visualized in figure 8. The first phase (*plan*), revolves around developing a plan with expected outcomes. The second phase (*do*), focuses on the implementation and execution of the plan. The third phase (*check*), evaluates if the set plan was followed and if the expected outcomes were achieved. The fourth phase (*act*), aims to review the progress, which is followed by an assessment of further improvements. These four phases are then conducted in an iterative manner, meaning that once the act phase is finished, the improvement activity is re-initiated at the plan phase with the new learnings. It is therefore often called the PDCA-cycle (Bhasin, 2015).

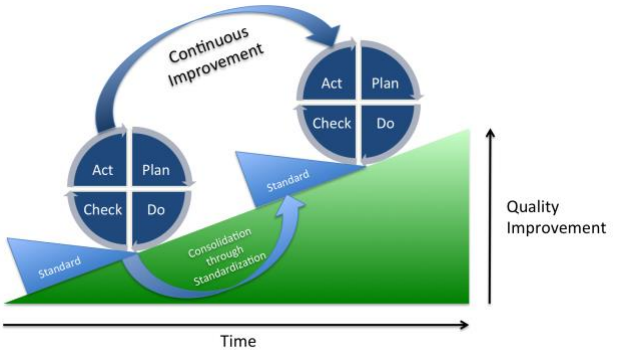

Figure 8, Demonstration of PDCA (Wikipedia, 2013)

Root Cause Analysis

Root cause analysis is a problem-solving methodology for approaching the underlying problem instead of having consistent firefighting activities. It is essential for continuous improvement to investigate, understand and solve the root cause rather than quick fixes, A popular approach in Lean for root cause analysis is the "5-Why's" which essentially means to question why an issue has occurred repeatedly until the core of the problem is identified (Bhasin, 2015).

Standardized Working Procedures

Standardized working procedures is emphasized within Lean as it eliminates waste by consistently applying best practices for recurring tasks. The best practices are standardized by following documented procedures of processes, such as manufacturing instructions and customer service, which are continuously updated. These documents create the foundation from which future improvement activities are based on (Bhasin, 2015).

Takt Time

Takt time demonstrates the maximum production time per unit in order to meet the customer demand. It is calculated by dividing the available production time with the rate of customer demand. For example, with a planned capacity per day of 480 minutes, and the demand is 20 units per day, the takt time is 480 min/20 units which equals a takt time of 24 minutes. Consequently, one unit must be completed every 24 minutes in order to meet the customer demand. By calculating the takt time, it is possible to pace the production in a simple, intuitive, and consistent manner which can be used as an efficiency goal for production by comparing daily output with the theoretical target (Bhasin, 2015).

Value Stream Box Score

The Value Stream Box Score (VSBS) is a spreadsheet technique used to specify measures and identify performance against Lean targets based on a value stream map, as exemplified in figure 9. It is a practice used to connect the financial perspective to the operational (Woehrle & Abou-Shady, 2010). According to Cunningham, Fiume and Adams (2003), the measurements must support the organization's strategy, be mostly non-financial, relatively few and easy to understand. Additionally, they must be structured to motivate a Lean behavior, that measures the process and not the people. The need for new KPIs when implementing Lean is crucial as traditional cost accounting is optimized for mass production which strictly contradicts the principles of Lean (Maskell & Baggaley, 2004). Basing the targets from a value stream point of view, one can instead review the future state of a value stream map and break it down into weekly targets which are necessary in order to reach the future state (Woehrle & Abou-Shady, 2010).

		Current State	Future State
Operational	Sales per Person	€5,000	€5,500
	On-Time Shipment	92%	94%
	Lead Time (Days)	33	24
Capacity	Productive	51%	46%
	Non-Productive	30%	14%
	Available Capacity	15%	29%
Financial	Revenue	€300,000	€330,000
	Value Stream Profit	€105,000	€110,000
	Material Costs	€110,000	€102,000
	Return On Sales	30%	35%
	Inventory Value	€209,000	€180,000
	Cash Flow	€130,000	€205,000

Performance measures reflects improvements as waste is eliminated

Eliminating waste transforms non-productive capacity into available capacity

Value-stream income statement measures profitability by value-stream

Figure 9, Demonstration of a Value Stream Box Score (VSBS)

Value Stream Mapping

Value stream mapping is a useful tool in analyzing the flow and resource allocation towards customer value, in order to reduce waste (Patrocinio, 2015). The value stream map considers all activities necessary for producing a product or service and depending on the scope it could range from external suppliers to a specific internal activity. The main purpose of using value stream mapping is to gain a deeper understanding of the flow and to visualize the non-value adding activities in the supply chain, to sequentially eliminate those activities (Patrocinio, 2015). A visual demonstration can be identified in figure 10.

The value stream mapping is conducted by timing the construction of a product or component throughout its value chain. Based on the timings, it is possible to define a map of the current value stream. The following steps to mapping the current state is to define a future state of a value stream map, where goals are set for elimination of the non-value adding activities (Liker, 2004).

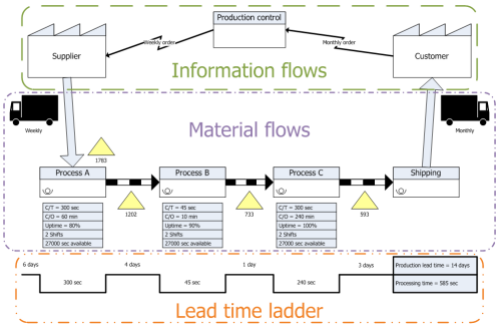

Figure 10, Visualization of a Value Stream Mapping (Wikipedia, 2013)

Visual Management

The concept of visual management in Lean is to simplify a process by creating visual support for the working procedures and to improve communication of information. These supporting visual tools can be floor markings, tool shadowing, visual operator instructions, and performance indicators. Utilizing these techniques provides an easily accessible update on the actual state and condition of the manufacturing processes and thus, increases the efficiency of the information flow for the employees (Bhasin, 2015; Cox & Ullmer, 2015).

2.3 Achieving Successful Lean Transformations

Several researchers have tried to develop appropriate measures to evaluate the success of Lean implementations or the degree of "leanness" in manufacturing companies. Although efforts have been made to develop a degree of "leanness", there is still missing an effective estimation that provides a meaningful link between the implementation of Lean, the Lean maturity and its financial gains (Yadav et al., 2017). However, there are research regarding the success factors and key activities in Lean implementations that are vital for effective Lean organizations. Presented below are identified success factors within Lean implementations, which is based on two comprehensive publications. Sisson and Elshennawy (2015) present their 17 principles of successful Lean improvements and Shah and Ward (2007) present their 10 dimensions of a Lean system. The study by Sisson and Elshennawy (2015) presents a thorough literature review based on 46 articles, presenting 17 key success factors for a Lean implementation. These factors were validated in a multiple case study of four world class Lean organizations in different industries, with a proven successful Lean culture of minimum 15 years. Shah and Ward (2007) are frontiers

in the development of measurements in Lean production, through their extensive data collection consisting of a literature review of 68 articles, a pilot study and a confirmatory analysis based on 295 survey responses. The six key constructs by Sisson and Elshennawy (2015), with the support of 10 dimensions of a Lean system by Shah and Ward (2007), have been utilized to demonstrate the success factors within Lean management.

2.3.1 Six Key Constructs of Successful Lean Improvements

An established research on success factors is provided by Sisson and Elshennawy (2015). The authors provide 17 success factors (see full list in Appendix 1) which are categorized into six areas: Deployment, Engagement, Training, Processes, Drivers, and Culture.

Deployment

The first success factor suggests that a Lean implementation benefits from being initiated by top management. In instances where a non-managerial employee who is passionate about Lean initiates a "grass-roots" deployment, the chance for success is low. Although it is possible to drive some Lean efforts as a blue-collar employee to eventually get the attention and support from top management, an implementation initiated by executive leadership has a significantly greater chance to succeed (Mann, 2014). The importance of leadership and top management involvement has been stressed repeatedly in literature as one of the key factors for successful implementations and participating in Lean activities by being directly involved is one of the best ways to show commitment (Sisson & Elshennawy, 2015). Additionally, Timans, Antony, Ahaus and van Solingen (2012) found that the personal experience of Lean within top management was a decisive success factor which is supported by Emiliani and Emiliani (2013) who identified that managers must not only support Lean but also understand the concept thoroughly and apply it to their day-to-day activities.

Another strategy that has proven to be beneficial during deployment is the use of Senseis. A Sensei is a teacher and mentor who has mastered Lean implementations through multiple experiences (Sisson & Elshennawy, 2015). The Sensei acts as a coach who is an objective outsider that mentors executive leaders to become Lean (Malone, 2013).

A key factor during Lean implementations is to ensure that the deployment is conducted throughout the organization. In fact, one of the main reasons why Lean implementations fail is due to the narrow focus on manufacturing and shop-floor activities. By only focusing on manufacturing activities, it has been proven to be difficult to sustain the improvements in shared processes to other support functions. It is therefore crucial to extend the Lean implementation to other areas such as sales, purchasing, and product development (Sisson & Elshennawy, 2015).

Similar to the previous success factor, it is important to extend the Lean implementation to suppliers once an organization has had internal success of Lean. Not only does it benefit from a

logistic- and financial perspective, but also provides an opportunity to further develop the knowledge and expertise of Lean (Koenigsaecker, 2016).

Consequently, the success factors for deployment are:

- ***Success factor #1****: Successful Lean companies drive the implementation top-down.*
- ***Success factor #2****: Successful Lean companies utilize consultants from established Lean companies like Toyota as senseis to help guide their initial learning and Lean improvement.*
- ***Success factor #3****: Successful Lean companies implement Lean in both manufacturing and non-manufacturing areas.*
- ***Success factor #4****: Successful Lean companies recognize that once they have made progress with becoming Lean internally, they must extend it to their suppliers.*

Engagement

Creating an environment that allows for involvement and engagement is a key factor for implementing and sustaining a Lean transformation. To create such an environment, an organization must dedicate full-time resources (Sisson & Elshennawy, 2015). In accordance, Koenigsaecker (2016) recommends that roughly 3 % of an organization should be devoted to Lean. Furthermore, as slack resources are gained through Lean improvement efforts, these can be allocated to the Lean team to develop the group further.

Another key issue for engagement in Lean implementations is communication. Communication is essential when any major changes are made in an organization and is fundamental for employee engagement. Especially for extensive organizational changes, such as Lean implementations, where the employees are often asked to completely change their behaviors and way of thinking. Koenigsaecker (2016) suggests that it is impossible to "over-communicate" when implementing a change that restructures the organizational strategy. A Lean transformation should be explained through various communication channels like meetings, videos and newsletters. Furthermore, Brown (2012), claims that communication and especially discussions with employees for feedback should occur many more times than what is often believed to be necessary.

There are numerous human resource policies that are essential for supporting a Lean implementation. Incentives such as increased pay or bonuses can be based on the performance of Lean targets rather than on piece-rate production which promotes overproduction, i.e. waste. Additionally, it is vital to ensure job security and clarify that employees will not be fired as a result of slack resources due to Lean improvements (Sisson & Elshennawy, 2015).

The organizational structure can also be based on a Lean hierarchy, meaning that there are opportunities for promotions through engaging in the Lean transformation. The HR management are also responsible of ensuring that the right set of skills for Lean exists within the organization

(Sisson & Elshennawy, 2015). According to Alagaraja (2013), it is important that the HR department is involved in the development of Lean training programs and designing a recognition system that inspires Lean improvements.

Consequently, the success factors for engagement are:

- ***Success factor #5****: Successful Lean companies dedicate full-time resources on Lean improvements.*
- ***Success factor #6****: Successful Lean companies seek to provide regular communications on Lean throughout the organization.*
- ***Success factor #7****: Successful Lean companies adopt HR policies that support Lean goals.*

Training

An essential part of any Lean implementation is the training and development of employees. It is critical when implementing any kind of business strategy to have the necessary training, particularly in Lean (Sisson & Elshennawy, 2015). Liker and Convis (2012) claim that having a deep time consuming and expensive investment for employee development is the recipe for success. According to Bhasin (2012), one of the main factors for failed Lean implementations is lack of adequate training. It is also important that the training is an ongoing process and regularly revisited, and employees should be provided with opportunities to participate in improvement activities as a part of the training (Sisson & Elshennawy, 2015).

Another key factor is to develop internal leaders that supports a strong Lean culture. Training is often conducted by using external Senseis to coach internal leaders over a few years. Once the external consulting from the Senseis is completed, the internal leaders must be developed so that they can sustain and lead the transformation afterwards (Sisson & Elshennawy, 2015).

Consequently, the success factors for training are:

- ***Success factor #8****: Successful Lean companies invest in training for employees to learn about Lean.*
- ***Success factor #9****: Successful Lean companies see value in developing internal Lean leaders and senseis.*

Processes

A fundamental issue in any Lean transformation is deciding how processes should be managed. It is crucial to understand how the organization converts inputs into outputs which are aligned to the customer needs. The most common tool for this is value stream mapping (Sisson & Elshennawy, 2015). The value stream map provides useful insights on the information and material flow of the current and a future, desired state. According to Koenigsaecker (2006), creating a corporate-wide value stream map by senior management is important when initiating a Lean implementation as it allows for accurate resource allocation and where opportunity possibilities exists.

Another key factor for processes in Lean is to implement and sustain standardized working procedures (Sisson & Elshennawy, 2015). Standardized work means that the current best approach performing an operation is documented and standardized. Once a better approach for the task is found, the previous standard is scrapped and the new one is standardized. Koenigsaecker (2016), claims that standardized work is one of the key components for a successful Lean manufacturing as it is essential in any efforts related to continuous improvement.

The last key factor for processes in Lean implementations is policy deployment, also known as hoshin kanri (Sisson & Elshennawy, 2015). The concept of hoshin kanri is to take the enterprise-wide strategy in consideration and break it down into simple, relevant objectives for each level in the organization (Liker & Morgan, 2006). This enables specific improvement projects to be clearly linked to the Lean culture and the general vision of the organization (Sisson & Elshennawy, 2015).

Consequently, the success factors for processes are:

- ***Success factor #10****: Successful Lean companies utilize value stream mapping to identify and drive improvement opportunities.*
- ***Success factor #11****: Successful Lean companies utilize standard work as a baseline for continuous improvement.*
- ***Success factor #12****: Successful Lean companies utilize Hoshin Kanri or policy deployment to align company goals and Lean strategies.*

Drivers

One of the key drivers in Lean are the customers. The voice of the customer (VOC) expresses what is actually considered to be value which should be the main focus when implementing Lean. It is important that the VOC is at the core of every product and process. Therefore, a key success factor in Lean implementations is to create a culture where the customer is the focus throughout the organization and a driver for improvements (Sisson & Elshennawy, 2015).

Another success factor for drivers is the utilization of Kaizen to create a continuous improvement culture. Koenigsaecker (2016), suggests that having Kaizen experiences is vital to develop a self-sustaining Lean improvement. These Kaizen events should occur regularly and involves both shop-floor workers and senior management. By enforcing senior management to participate, it can motivate to devote further resources when they see waste for themselves during the events (Sisson & Elshennawy, 2015).

Other measures for building a continuous improvement culture can be to develop key performance indicators (KPIs) which supports an improvement culture. It is important that these metrics are both financial and non-financial, with the ultimate goal of achieving customer satisfaction. These KPIs can then be presented throughout the organization with the use of visual management. It is

an important success factor in Lean implementations to develop and clearly visualize the current performance to further drive the Lean implementation (Sisson & Elshennawy, 2015).

Consequently, the success factors for drivers are:

- ***Success factor #13****: Successful Lean companies use the Voice of the Customer (VOC) as a driver of improvements.*
- ***Success factor #14****: Successful Lean companies utilize Kaizen at a regular cadence to drive continuous improvements*
- ***Success factor #15****: Successful Lean companies utilize appropriate metrics and visual management to drive Lean improvements*

Culture

The final construct for successful Lean implementations regards the importance of organizational culture. It is essential for Lean implementations to create a strong set of beliefs and practices which is in line with the Lean philosophy. A common approach is to create an own document which is similar to Toyota's TPS. However, it is crucial to understand the purpose and principles behind the TPS and then analyze how those could be relevant for their own company (Lander & Liker, 2007). It should not be just be a simple presentation which is quickly forgotten but rather the backbone of the organization which guides through day-to-day operations (Sisson & Elshennawy, 2015). The success factor refers to define such a document and thereafter truly embrace it within the organization.

It must also be recognized that developing a Lean culture takes time. According to Koenigsaecker (2005), fully developing a Lean culture usually takes at least a decade. This has been proven to be a major issue when implementing Lean in the Western culture where management often values fast results rather than long-term focus (Quinn, 2005). It is therefore a decisive factor whether or not organizations recognize that the implementation will take time and have a long-term focus rather than a short-term (Sisson & Elshennawy, 2015).

Consequently, the success factors for culture are:

- ***Success factor #16****: Successful Lean companies have their own version of the Toyota production system that is not just a document but a significant part of the company's culture*
- ***Success factor #17****: Successful Lean companies recognize that developing a Lean culture is a lengthy process and that Lean is never-ending.*

2.3.2 10 Distinct Dimensions of a Lean System

Shah and Ward (2007) identified 10 factors by synthesizing 48 tools and practices that represent the operational space surrounding Lean production. The correlation between the 10 factors are statistically significant ($p < 0.001$), which thereby assist to the multidimensional and integrated nature of Lean production systems. They argued that “the complementary and synergistic effects

of these ten distinct yet highly interrelated factors provide Lean production with a unique character and a superior ability to achieve multiple performance goals" (Shah & Ward, 2007, p.800). The authors argue that these 10 factors demonstrate the operational complement to the philosophy of Lean production which also characterizes 10 distinct dimensions of a Lean system. Even if each factor itself implies better performance, organizations implementing the complete set will be able to reap significant performance improvements and gain sustainable competitive advantage. The 10 factors can be divided into three areas; supplier involvement, customer involvement, and internal issues. Furthermore, these areas can be correlated to the soft and hard practices by Bortolotti et al. (2015), where supplier involvement and customer involvement can be referred to as soft practices and the internal issues as hard practices.

Supplier Involvement

Firstly, an organization should provide regular *supplier feedback* regarding their suppliers' performance. Secondly, the authors stress for *JIT delivery by suppliers* which ensures that the organization receives the right quantity, at the right time, in the right place. The third factor refers to *supplier development* in order to increase their involvement in the manufacturing process.

Customer Involvement

A central aspect of Lean is customers as they define what value is. In accordance, Shah and Ward (2007) claim that *customer involvemen*t is a key aspect, where a focus on the customer and their needs requires significant emphasis.

Internal Issues

The authors propose six factors which concern the internal operations of an organization. *Pull* is emphasized in order to facilitate JIT production and Kanban cards to signal start or stop of production. In addition, it is important to set mechanisms to facilitate the *continuous flow* of products. Another issue is the process downtime between product changeovers, and therefore an organization should aim for *set up time reduction*. Furthermore, *total productive/preventive maintenance* to address equipment downtime to attain a high level of equipment availability. Shah and Ward (2007) conclude with *statistical process control* to avoid defected units and *employee involvement* to improve problem-solving and cross-functional integration.

2.4 Change Management

Changes in an organization are necessary when their current operations can no longer keep up with their competitors or customer demands. The required significant organizational changes imply uncertainty, ambiguity and anxiety for the affected employees (Nadler & Tushman, 1997). The transition of individuals, teams or the whole organization requires significant emphasis towards different obstacles that might hinder the transformation. The purpose of change management is to guide the process from the current state to a desired future state. Additionally, AlManei, Salonitis

and Tsinopoulos (2018) define change as the "behavioral shift of the organization as a whole, from one being to another". In this definition, it is evident that change requires a behavioral shift, meaning that individuals representing the organization will have to change their day-to-day behaviors. Thereof, changing the organizational culture is a key issue in succeeding with change initiatives. However, changing the culture takes time as it is deeply rooted in the history of the organization, which is structured and formulated gradually over time (AlManei et al., 2018). Changing the employee behavior has been proven by both practitioners and academics to be a great challenge and change processes during the implementation phase have been linked with a failure rate of 70 %, mostly due to ineffective planning and employee resistance (Beer & Nohria, 2000). In accordance, Nadler & Tushman (1997) stress the importance of overcoming the resistance and gaining critical mass of support in order to achieve successful change implementations. Similar trends are shown for Lean implementations, with lower success rates than 10% for organizations in the UK and automotive plants in the U.S., and India (Baker, 2002; Mohanty, Yadav & Jain, 2007).

Evidently, change management is a vital aspect in extensive transitions. Therefore, this chapter intends to provide an overview of the traditional change management theories, which is further specified into a Lean implementation context.

2.4.1 Traditional Change Management Theories

Schein (1996) argue that Lewin's basic change model can be considered as the theoretical foundation for change practices. The model is composed of the three phases called *Unfreeze*, *Change* and *Refreeze* (see figure 11).

Figure 11, Representation of Lewin's basic change model

The first phase is considered to be particularly important, since establishing a need and setting the plan for change will affect the success of the upcoming stages. The second phase revolves around the implementation of the change that was planned during *Unfreeze.* This is a complex stage as opposition towards the change can be expected, due to involved employees experiencing uncertainty, ambiguity and anxiety. After overcoming the resistance and executing the change, the organization enters the final phase. The *Refreeze* phase concerns the standardization of the new practices and procedures, where the new norms are set. Researches have shown that this phase often is not emphasized enough, with insufficient time being delegated towards it. Therefore, it is common that most companies fail in sustaining the change and instead falls back into old patterns and habits (Nightingale & Srinivasan, 2011; Schein, 1996).

The three phases in Lewin's basic model can be utilized to group Kotter's 8-step model, as visualized in figure 12. During the preparation phase before a change, it is important to make the organization realize that there is a need for change, through presenting facts or arguments, as strong motivation and participation among the employees will facilitate the transition. Kotter (2007) suggests that key issues towards achieving this state covers the steps: *Establish a Sense of Urgency, Forming a Powerful Guiding Coalition and Creating a Vision.* Following these three steps will limit the uncertainty among employees, and they will become more acceptant to changes. This results in employees being more open to new ways of working and will most likely adjust to new approaches. The change phase concerns another three steps, which include *Communicating the Vision, Empowering Others to Act on the Vision and Planning for* and *Creating Short-Term Wins.* To succeed in this phase, it is important to maintain continuous communication, and prove the importance of new approaches. The final phase includes the two last steps, *Consolidating Improvements and Producing Still More Change* and *Institutionalizing New Approaches.* During this stage there is significant emphasis towards sustaining the changes and preventing employees from adopting their old habits. This implies anchoring the changes in the organizational culture, where additional support and training is provided to ensure that the new approaches gets institutionalized (Kotter, 2007).

Figure 12, Demonstration of the steps in Kotter's 8-step model

There are still discussions regarding where the change should be initiated. Some authors argue that bottom-up initiatives are preferable, while others motivate for a hybrid between bottom-up and top-down. Nightingale and Srinivasan (2011) claim that although a transform must develop into a hybrid initiative over time, it is vital that the initiative starts from the top. The authors demonstrate that the involvement of every stakeholder relies on the senior leadership team leading the change by example. Full commitment and motivation from employees are a product of the enterprise leadership team dedication, which are accountable for the progress and success of the transformation. The importance of leadership engagement derives from its possibilities in engaging employees at all levels of the organization. To make this feasible, it is crucial that the leaders understand the context and the culture of the organization. Once the culture is understood, the leader will further have to shape the culture in order to support for continuous organizational transformations. Lastly, Nightingale and Srinivasan (2011) conclude that an engaged leadership team will facilitate the distribution of the change initiative, which thereon becomes the preferable hybrid, with continual iteration between top-down and bottom-up.

2.4.2 Change Management within Lean Implementation Context

Change management within extensive organizational transitions, such as Lean, can be explained through the traditional change management theories. However, AlManei et al. (2018) provide suggestions on how to sequence the implementation of Lean production, following Kotter's 8-step model, in order to facilitate the change process. In addition, the authors present a Lean tools roadmap (see figure 13) which proposes an order for the implementation of well-established Lean tools and practices based on their required Lean maturity. The model considers the foundation of the house of Lean, *Standardization* and *Stability*, to include low maturity tools which are easier to implement. Common techniques within this phase are 5S, Kaizen and standardized working procedures. These tools are advantageous during the early implementation stage as they are easy to communicate, provides short-term wins and empowers the employees, i.e. supporting the steps of Kotter during the change. Continuing steps include the techniques used to support the pillars constituting of Jidoka and JIT. These concepts are more abstract to grasp and require a higher Lean maturity. The tools within these pillars are for instance, Poka-Yoke, Problem Solving, Andon, SMED, Heijunka, Takt time, One-piece flow and Pull production. Furthermore, the authors conclude that the sequencing of tools should be adapted to the needs and the Lean maturity of the organization (AlManei et al., 2018).

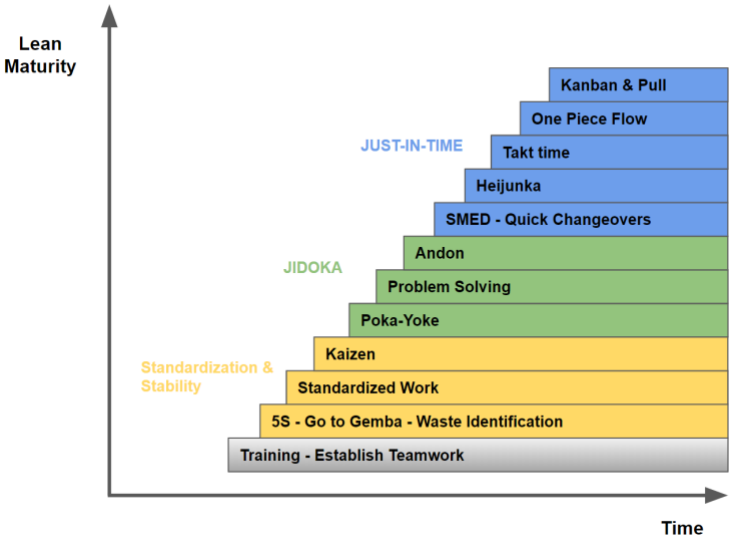

Figure 13, Illustration of suggested sequencing of Lean tools by AlManei et al. (2018)

Various authors claim that the underlying reason for Lean implementation failures derives from insufficient understanding of Lean concepts and practices (Yadav et al., 2010). In fact, several organizations believe that implementing Lean implies adopting the traditional Lean tools in a rather sequential matter. Conducting a root cause analysis, 5S or value stream mapping are effective individually, but their scope is limited which requires strategic planning. Applying these tools everywhere without considering the enterprise's strategic objectives will not assist in an enterprise transformation. Hence, it is required that the entire organization adopts a holistic perspective where leaders understand that continuing with local improvements through Lean tools, without enterprise thinking, will not transform the whole organization. Understanding the difference between improvement and transformation is vital when implementing Lean, and even though local improvements are necessary, they will only provide limited success. It is important to acknowledge that concerning the whole of improvements that are connected to the wider enterprise objectives, will generate greater impact than the sum of each improvement. The enterprise thinking also ensures that all improvements generate increased customer value, which is the main focus in Lean. The holistic view is, however, often missing which claims to a major cause to why most Lean transformation efforts fail (Nightingale & Srinivasan, 2011).

3. Method

A method aims to, scientifically, process a topic in order to reach a result. The method affects how the study is performed and is consistently revised throughout the study (Ejvegård, 2009). There are different techniques, also called methodologies, for collecting material to describe, compare and create hypotheses. The data collection can be conducted through the use of tools such as interviews, observations, questionnaires, and experiments. It is the selection and utilization of these tools that define the design of the study (Ejvegård, 2009).

This chapter begins with a presentation of the utilized research design, where the approach and data collection methods are described in detail and motivated for. Following, a discussion about the quality of the data regarding credibility, transferability, dependability, and confirmability. Lastly, the chapter is concluded with the ethical considerations of this research considering affected parties of the study.

3.1 Research Design

Generally, research can either be deductive or inductive. The deductive approach aims to test existing theories, while the inductive approach attempts to create theory as a result of observations. With a purpose to investigate how Lean can be implemented, but also to identify upcoming challenges, this study has used a combination called an abductive approach (Bryman & Bell, 2003). This also implies different types of data collection methods, i.e. interviews, observations, literature review, and historical data review. The methods have primarily generated qualitative data, but also a certain degree of quantitative data to support evaluations.

The route for the thesis is illustrated in figure 14, with the vertical arrow representing the sequence of the study. The arrows between Theoretical Framework and Empirical Data visualize the iterative approach, which has characterized the study by continuously switching between theory and practice. The figure is also shaped as a funnel, implying that the initial phases had a broader approach to the subject, which along the studies has been concretized into more specific details. Lastly, the funnel narrows into conclusion, and the arrow extends for future research.

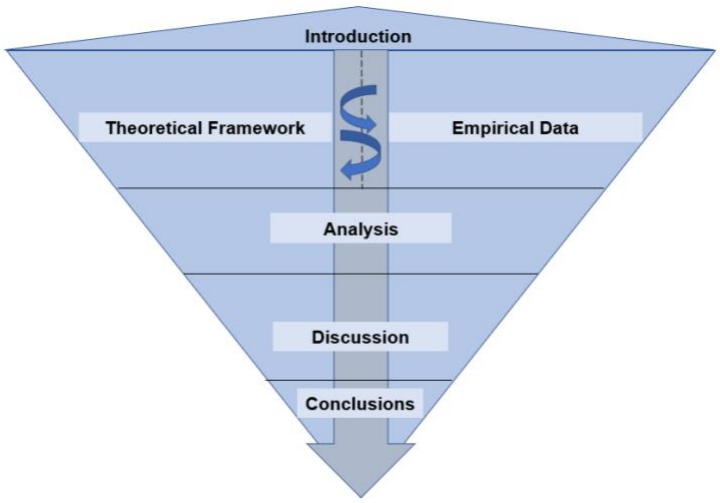

Figure 14, Illustration of the route of the thesis

3.1.1 Literature Review

The literature review has been a fundamental part of the data collection in order to deepen the knowledge within the Lean philosophy and change management theories. It is important to get a theoretical basis within the topic as it will detect shortcomings and gaps in the existing knowledge, which indicates the actual relevance of the research area. The literature review also shows how concepts in the area have been defined, specified and used in the current context (Backman, 2016). In total, 65 publications have been processed within relevant areas. The literature review has been the supportive methodology for research question one and two, with literature retrieved from Chalmers Library and Google Scholar, by the use of the keywords presented below. The relevant literature has also been used in connection to the interviews and observations as a foundation for the analysis. For instance, the literature review created a knowledge basis within Lean and Change management, where the six key constructs for successful Lean implementations by Sisson and Elshennawy (2015) have assisted in the design of the interview template (see Appendices 1 and 2).

Keywords used in literature review: *Change management, Employee Resistance, Lean Manufacturing, Lean Implementations, Lean Management, Organizational Change.*

3.1.2 Case Study

Case studies enable a characterization of the reality. It is often conducted by looking at a minor process of a major system, which is used to conclude that the bigger system works in a similar way as the smaller one. By using this methodology, the reality is described in a simplified way which is time and cost-saving. However, it may be misleading if the studied case differs from the rest of the system. Therefore, it is important to acknowledge any significant abnormalities when conducting a case study. In addition, case studies can consist of both qualitative and quantitative research methods (Ejvegård, 2009).

The project included interviews, observations, literature review, and historical data review. The case study has been ongoing for the full duration of the study, with observations and informal interviews conducted on a daily basis with managers and operators. In order to get a better understanding of the production process and the impact of Lean, 73% of the time (500 hours) has been spent in the shop-floor area. The case study has been a supportive methodology for research question two and three.

Quantitative Data Collection

Quantitative methods are when mathematics and statistics are used to make measurements and quantifications. Quantitative methods result in numerical data and can, for example, be experiments, historical data, sample surveys and questionnaires (Backman, 2016). In this inquiry, quantitative data will be collected from observations and historical data. This data will then be

used to statistically determine if there have been improvements in the case company's capabilities to determine if the implementation was successful. The data collected has been timings for production lines, performance indexes and waste analysis.

Qualitative Data Collection

Qualitative methods, unlike the quantitative methods, are characterized by the fact that they do not consist of numbers. This means that the formulations are reported in writing or verbally. Examples of qualitative methods are interviews and observations (Backman, 2016). Observations are conducted when reality needs to be investigated, which collects information from the situation (Backman, 2016). Unlike, for example, the interview method, observation enables the possibility to get information that the interviewee is unaware of, regarding the studied area (Justesen & Mik-Meyer, 2011).

The term interview can be defined as an exchange of information between two people who discuss a topic of common interest (Justesen & Mik-Meyer, 2011). Interviews are not always conducted in the same way and can be different due to the purpose (Ejvegård, 2009). For example, one characteristic is a very loosely structured conversation where the interviewee has the opportunity to speak relatively freely. On the contrary, the interview can be conducted through a carefully prepared interview-guide. Consequently, interviews can be divided into unstructured, semi-structured and structured categories (Ejvegård, 2009).

The qualitative data collection consisted of observations and, informal and formal interviews. The observational studies included observations in the shop-floor (500 hours) and weekly one-hour Lean meetings and other Lean activities in the offices (180 hours). The informal interviews regard to the non-recorded and unstructured daily discussions with managers and operators regarding issues in the Lean implementation. Approximately, 100 hours in total was dedicated to these types of conversations, in order to broaden our perspective. In addition to the informal, unstructured interviews that have been conducted on a daily basis, the study also included eight formal semi-structured interviews with representatives from different departments of the organization. The semi-structured interviews included the Quality Manager, Purchasing Manager, Lean Manager, Project Leader (based in the UK), Plant Manager, Financial/HR Manager, and one line operator. The semi-structured interviews allowed for an informal discussion where the interviewees had the freedom to express their views in their own terms. More details about the interviews can be found in table 2. The designed interview template consisting of 50 questions can be found in Appendix 2. Since they were conducted in a semi-structured format, some questions were modified or investigated further depending on the purpose of each specific interview. The semi-structured interviews were conducted by having two interviewers, one leading the interview and mainly following the prepared interview template. The other interviewer took notes and added additional follow-up questions. In addition, before every interview, the interviewee was asked for permission to be recorded, presented with the purpose of the interview and clarifications regarding their

anonymity. Once the interview data had been analyzed, all participants were consulted to review the content to ensure that no misinterpretations or violations of anonymity had taken place.

ID	Role of Interviewee	Topic of interview	Duration (min)
Interview 1	Quality Manager	Followed the interview template, with emphasis towards the product quality at Gunnebo Entrance Control S.p.A.	50
Interview 2	Purchasing Manager	Followed the interview template, with emphasis towards the implementation of ERP, MRP and CRP and plans for supplier involvement.	55
Interview 3	Lean Manager	Followed the interview template, but also added a thorough discussion regarding the utilized Lean tools since the beginning of the Lean initiative in 2016.	110
Interview 4	Line Operator/new Mizusumashi	Followed the interview template, with the main intention to gather the overall feeling among the blue-collars	50
Interview 5	Project Leader	Followed the interview template and validated the change process that was gathered from interview 3.	60
Interview 6	Plant Manager	Followed the interview template and discussed the change on a more strategic level and how it affected the plant.	30
Interview 7	Financial & HR Manager	Short interview to ask HR specific questions, such as if the transformation has caused resistance and if it has required discussions with labor unions.	15
Interview 8	Lean Manager	Concluding interview to verify the empirical data. The sequencing of Lean tools was further discussed, with the framework as a reference, to fully validate the transformation process.	180

Table 2, Additional details about the interviews

The qualitative data, from interviews and observations, has been used as a complementary source of information to provide a better insight into the organization. Furthermore, the intention with the observational study was to gather information regarding material- and information flows within the supply chain, challenges that arose during the implementation and how they managed these.

3.2 Research Quality

Reliability is defined as the trustworthiness of the data collection and analysis with respect to random variations. In order to achieve strong reliability, data collection and analysis need to be carefully processed (Höst, Regnell & Runeson, 2006). The quality of the research can further be evaluated through the four concepts; credibility, transferability, dependability, and confirmability.

Credibility demonstrates the validity of the research. Validity examines the link between the investigated object and what is actually measured. In order to increase validity, triangulation can be applied, i.e. studying the same object with different methods (Höst et al., 2006). Multiple research methods, as described earlier, were used to complement each other in order to approach this issue. In this case, triangulation was approached by complementing interviews with historical data and the authors' personal observations. Transferability refers to the extent it is possible to generalize the results from the research. By limiting the study to only one organization, there might be some transferability issues, meaning that the result might only apply to the specific case. However, by comparing literature to our observations, it is possible to determine if similar tendencies are shown for other cases. Dependability determines to what extent the study can be replicated. The dependability is considered through careful documentation, by taking photos and continuously updating project diary, throughout the progress of this study. Lastly, confirmability regards the objectivity of the study, i.e. the level of bias. To mitigate this factor, multiple actors will review the qualitative data to minimize interpretations and the literature review will be compared between multiple authors to identify any contradictions.

3.3 Ethical Considerations

Bryman & Bell (2015), defined four main areas of ethical principles in business research:

- Whether there is harm to participants;
- Whether there is a lack of informed consent;
- Whether there is an invasion of privacy;
- Whether deception is involved.

These principles will be taken into consideration when conducting the study. It is important to mitigate the risk of these principles to ensure that the respondents are provided with prerequisites for a safe information sharing environment. For example, all participants will be kept anonymous. The findings will be handled confidentially and evaluated before publishing, where affected parties will be consulted. Furthermore, this study is solely intended to study and contribute to a deeper understanding of Lean implementations, and not to put blame on any individuals or departments. Interviewees and observed systems will be treated confidentially and nothing will be published without permission.

4. Empirical Data

This chapter intends to briefly introduce Gunnebo Group, the branch Gunnebo Entrance Control S.p.A. and their related product offerings. In addition, the previous state and the motivation behind the Lean initiative are presented, which is followed by a description of the current state and the Lean transformation process. Lastly, the challenges and change management aspects are covered which are based on daily observations and conducted formal and informal interviews with managers and operators.

4.1 Gunnebo Group

Gunnebo Group is a worldwide leader in providing products, services, and solutions in the security industry. The group has sales companies and production plants distributed on a global scale, with the head office located in Gothenburg, Sweden. The Gunnebo Group has 4,449 employees and a turnover of 5,128 million SEK with an EBITA of 344 million SEK, equaling an EBITA margin of 6.7 % (Gunnebo Group, 2019).

The origin of the organization leads back to 1764 when Hans Hultman founded a forge which later became a well-established metalworking company. In the 1990s a venture capital firm acquired the business and the Gunnebo name was chosen to represent the group of security brands. The group consists of nine brands (with respective logos in figure 15): Gunnebo, Hamilton, Chubbsafes, Sallén, Steelage, Rosengrens, Gateway, Minimax, and Elkosta. The Group's brand strategy defines the profile and positioning for each of these brands and determines how they should be used to generate the most value. From these brands, the group offers products and services mainly for Cash Management, Entrance Security, Safes & Vaults, and Electronic Security (Gunnebo Group, 2018).

Gunnebo's business is organized into three sales regions: EMEA (Europe, Middle East & Africa), Asia-Pacific and the Americas. Across these three regions, Gunnebo has its own sales companies in 28 countries: 17 in EMEA, 7 in Asia-Pacific and 4 in the Americas. Through the group's extensive Channel Partner network, the coverage extends to over 100 additional markets. In addition to these sales companies, the Gunnebo Group has 10 manufacturing plants: 6 in EMEA, 3 in Asia-Pacific, 1 in Americas (Gunnebo Group, 2019).

Figure 15, Representation of all brands in Gunnebo Group

4.2 Case Company - Gunnebo Entrance Control S.p.A.

Gunnebo Entrance Control is a branch of the Gunnebo Group which is focused under entrance security with products and services for controlling and regulating access at key entry points. The department generates 20% of the Group Sales and has eight manufacturing plants. Today, there are over 70.000 Gunnebo gates installed worldwide and more than 90 million people that pass Gunnebo's entrance security gates on a daily basis in public buildings, airports, metros, and stadiums (Gunnebo Group, 2019).

Gunnebo Entrance Control S.p.A. refers to the production plant (visualized in figure 16) that is located in Lavis, Italy. The plant employs 70 people which operate in an 11.000 m^2 building, with a shop-floor of 3.100 m^2. There are 26 people working in the offices, and 44 working in the shop-floor, where 6 are temporarily employed. The production plant is certified for ISO 9001, ISO 14001, AEOF and their products are labelled with CE and GOST. The organization currently utilizes a typical hierarchical organizational structure as illustrated in figure 17. Every position with a functional responsibility is located in the UK (Gunnebo Entrance Control S.p.A., 2018).

Figure 16, Visualization of the production plant in Lavis

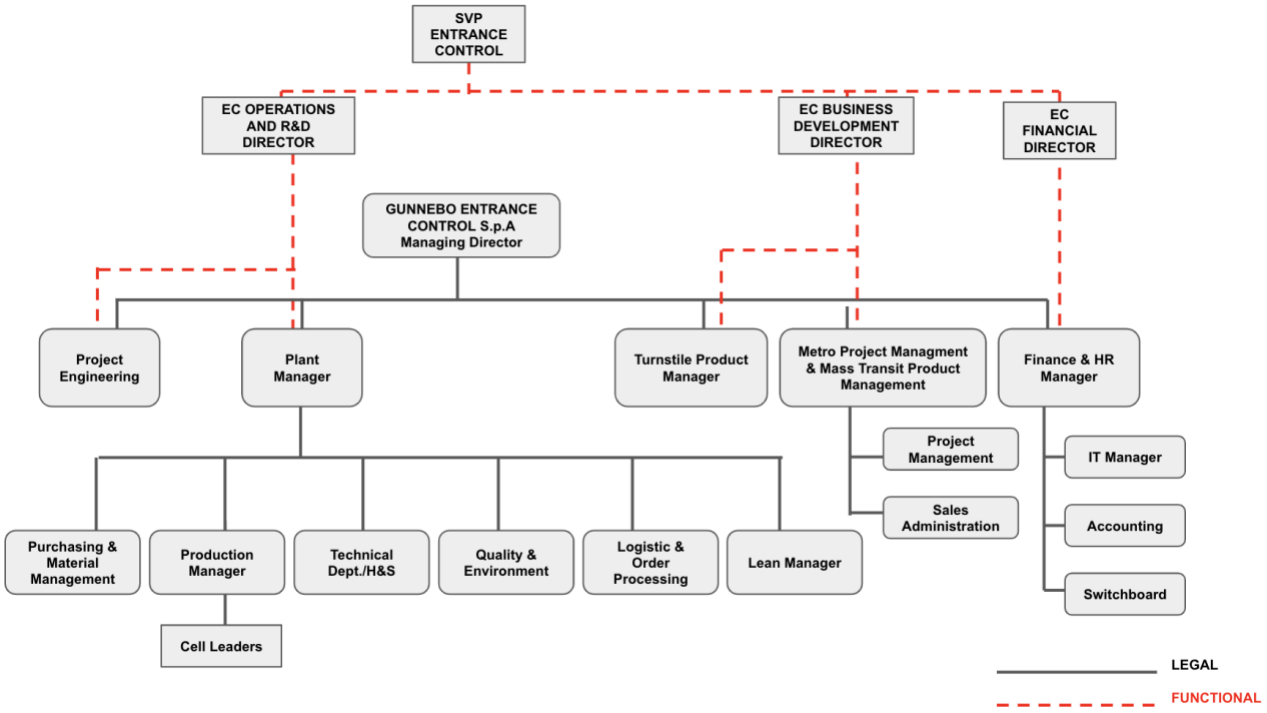

Figure 17, Illustration of the organizational chart for Gunnebo

Since the study only revolves around Gunnebo Entrance Control S.p.A., the terminology "Gunnebo" will hereafter refer to this manufacturing plant. In cases where the whole group or branch is considered, it will be clarified by the use of "Gunnebo Group" or "Entrance Control".

4.2.1 Product Descriptions

The production for 2018 constituted of the following product categories: Speed Gates, Tripods Turnstiles, Security Barriers, Entrance Gates, Full Height Turnstile, Remote Control Unit, Immsec, and Security Revolving Doors. Figure 18 demonstrates the order and piece distribution among these categories, with the Speed Gates representing 52 % of all orders for 2018 (Gunnebo Entrance Control S.p.A., 2018).

Price list category	%tot
A - speedgates	52%
B - tripods turnstiles	22%
G - security barriers	13%
D - entrance gates	10%
C - full height turnstiles	1.3%
E - remote control unit	0.8%
L - immsec	0.3%
F - security revolving doors	0.1%
Grand Total	100%

74% of orders
80% of pieces

97% of orders
97% of pieces

Figure 18, Demonstration of product order distribution for 2018

Product category A, Speedgates, refers to the products SpeedStile FLs, FL, BP, and FP, which are illustrated in figure 19. These gates are the more advanced product offerings with an extensive amount of customization options through a wide range of finishes, colors, and materials. The SpeedStiles are suitable for all areas where aesthetics, excessive flow, reliability, and security are highly demanded. By integrating access control devices, they provide high security and capacity in one solution that prevents unauthorized passage. These products will hereafter be referred to respectively as FLS, FLH, BP, and FP, with the primary two being the main focus in the Lean transformation.

Figure 19, Representation of product category A, Speedgates

Product category B, Tripod Turnstile, refers to the products SlimStile BA Lite, BA & EV, and TriStile RO, which are illustrated in figure 20. In combination with product category A, they represent 74 % of the orders and 80 % of the pieces, corresponding to the majority of their business. The Tripod Turnstiles are more simple, compact and cost-effective, but are still complex due to their several customization options. These products will hereafter be referred to as TOM.

Figure 20, Representation of product category B, Tripod Turnstile

Additionally, the product categories D and G refers to 10, respectively 13% of the orders for 2018, representing the products Point of Sale and GlasStile S, which are illustrated in figure 21. Even though they are produced in lower volumes, they are still delivered on a weekly basis. In combination with product category A and B, these products symbolize 97 % of the orders and 97 % of the pieces. The GlasStile S offers similar functions as product category A&B, while the Point of Sales solely focuses on controlling the flow of pedestrians through either mechanic or motorized swing gates. Point of Sale Turnstile will hereafter be referred to as PoS, and GlasStile S will be referred to as GS.

Figure 21, Representation of product category D & G, Point of Sale and GlasStile S

4.2.2 Gunnebo Operating System

The Gunnebo Operating System (GOS) is an internal document which represents the core values and vision of the operational strategy. It got established in 2013 and has been implemented in all plants of the Gunnebo Group to improve the efficiency of the production. The GOS embrace the Lean principles of maximizing the value for the customer, and it has a focus on continuous elimination of waste, see figure 22. The intention with GOS was to be the foundation for new strategies and decisions, which aims to assist in aligning the day-to-day activities to the core values, similar to the TPS of Toyota.

Even if the GOS has been a motivation for the Lean initiative, there is a divergence whether if it further has been utilized and communicated throughout the organization. The interviews revealed that GOS was a good starting point and provided great means for Gunnebo Group to introduce the Lean concept. However, its usability decreased when the group got split into different product areas, and the differences between the factories grew larger. This led to GOS not being updated, which consequently has left it unused over the last four years. The ideas with GOS have however been forwarded by the Lean manager as they share similar principles. Nonetheless, this has led to a decrease in information sharing of Lean progress within Entrance Control, and it does not happen at all on a group level.

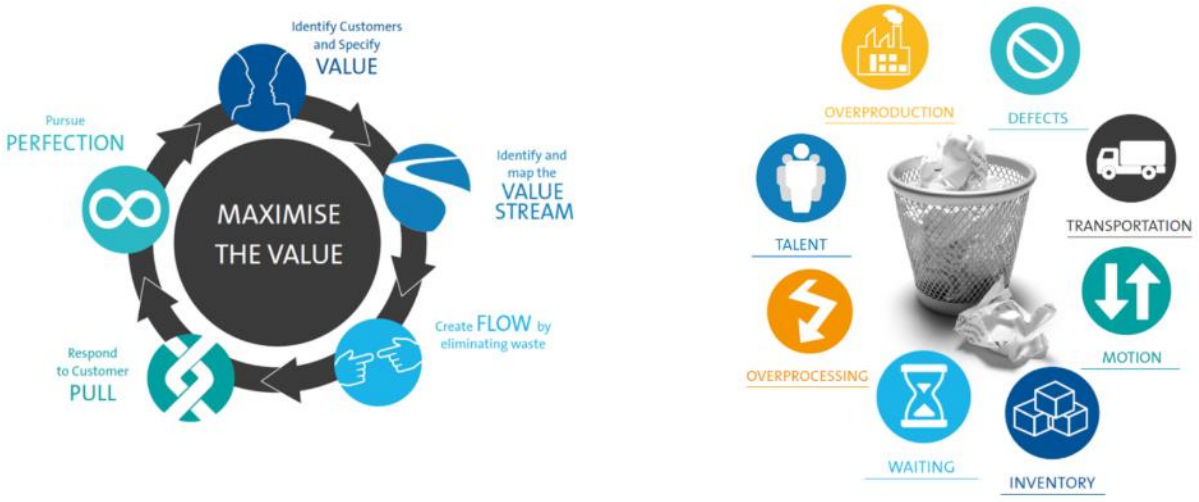

Figure 22, Representation of the core values for GOS and its focus on elimination of waste

4.3 Lean Transformation Project

An increase in market opportunities has led to Gunnebo being in need of increasing their capacity and flexibility, where limiting the lead times are seen as vital in order to get more contracts. This started a Lean transformation initiative in 2016, which in 2018 grew to a Lean transformation project, called the Golden Line. The Golden Line is a concept developed by Gunnebo and it refers to the creation of a perfect value stream focusing mainly on product category A and the

improvements of all related processes according to the Lean philosophy. In addition, in order to enable space for the Golden Line, the Lean initiative also covered the product categories B, D and G. The project aims to change the physical and informative flow, and moreover implement a Lean culture through training, Jidoka and Supplier Development. By focusing on these aspects, Gunnebo intends to change the organizational culture and behaviors towards a continuously learning and improving organization. In a quality perspective, the production already performed at a sufficient level and was therefore not a primary focus for improvements. The previous quality culture was therefore maintained, and whenever non-conformities were noticed, a root-cause analysis was conducted and preventative measures were applied.

The changes made by the Golden Line can be broken down into two areas. Firstly, the physical material flow which refers to changes in production such as the implementation of 5S, One-Piece flow, layout rearrangements, balancing of lines, Poka-Yoke and Mizusumashi. Secondly, the informative flow which refers to the implementation of Enterprise Resource Planning (ERP), Material Requirement Planning (MRP), Capacity Requirement Planning (CRP), Heijunka scheduling, visual dashboards, and standardized build instructions.

The Lean transformation project can be divided into four phases: the initial phase (prior to 2019), the first quarter of 2019, the second quarter of 2019 and the future state. The previous state, illustrated in figure 23, was characterized by spot improvement activities with an unclear direction, mainly focusing on relayout of the assembly lines to support the one-piece flow and improve space utilization. In addition, 5S activities had been conducted in order to improve the workplace organization. This was continued during the first quarter of 2019, with aligned improvements to support the Golden Line implementation, which was held during the second quarter of 2019. During the Golden implementation, the production lines were completely stopped for a full week to enable the extensive Lean transformation. With the total solution in place, Gunnebo further aims to refine and improve the implemented Golden Line to ensure that any issues are resolved and that the changes and behaviors are sustained. Thereafter, the intention is to include all product lines of standard products in the Golden Line concept. Through continuous development, they strive to reach a future state with a Lean culture which is characterized by all improvements being oriented in the same direction, with everyone involved and an organization that understands the Lean strategy and its principles.

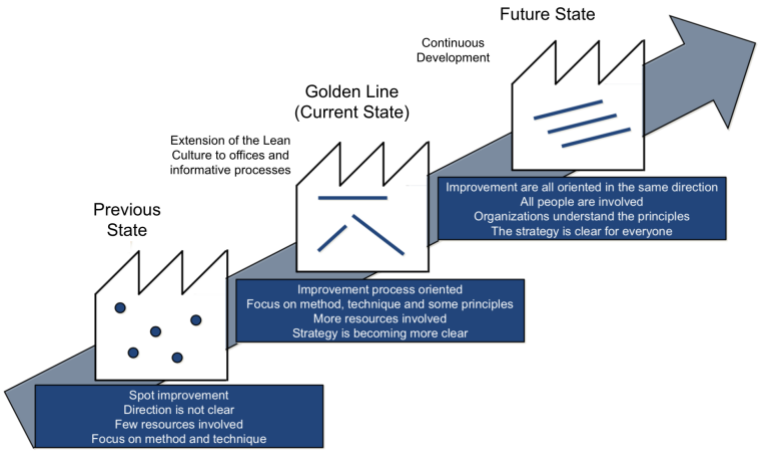

Figure 23, Demonstration of the intended direction with the Lean transformation

The subsections of this chapter aim to describe the Lean transformation in more detail, which is divided into previously mentioned phases, i.e. the initial phase, the first quarter of 2019, the second quarter of 2019 and the future state.

4.3.1 Initial phase of the Lean Transformation

The key activities during the initial phase of the Lean Transformation process, ranging from 2016 to 2019, can be visualized in figure 24.

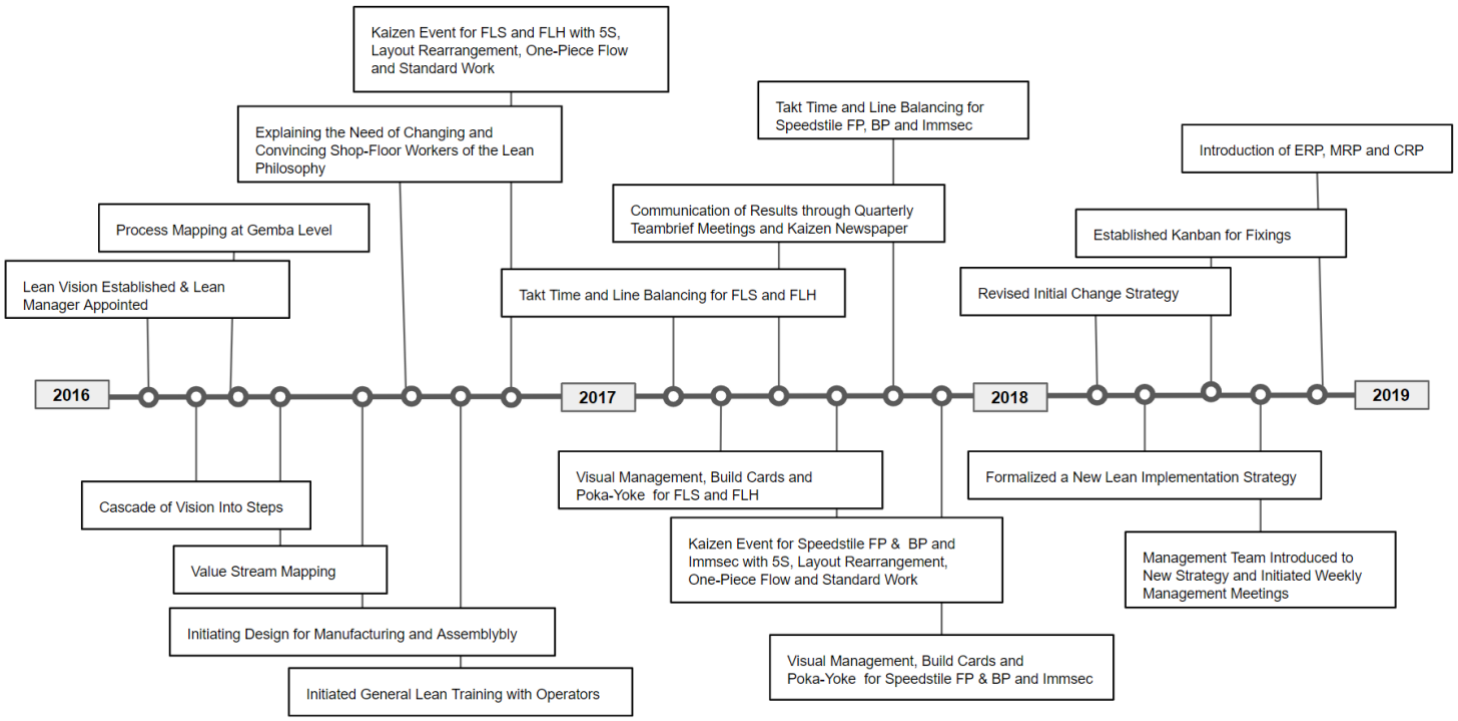

Figure 24, Demonstration of the key Lean activities during the initial phase of the transformation

The transformation was requested from the managing director as it was recognized that there was a need for change in the manufacturing plant. In 2016, the Lean initiative got introduced to Gunnebo and a Lean manager was appointed. The Lean manager cascaded the given vision into steps and the initial focus was to change one production line at a time. The initial phase of the Lean transformation was solely at Gemba level and did not include any other managers.

The layout of the production plant, prior to the Lean initiative can be seen in figure 25. The colored boxes demonstrate the location of the previous production, and all remaining areas are used as pedestrian and forklift alleys, or for inventory purposes. Furthermore, the color codes represent the product categories; yellow referring to the Speed Gates, purple to the Tripods Turnstile, green for the Point of Sale & GlasStile S. These processes involve the assembly, testing, and packaging of the product. Additionally, blue is given for individual projects, grey for preparatory work and brown for offices.

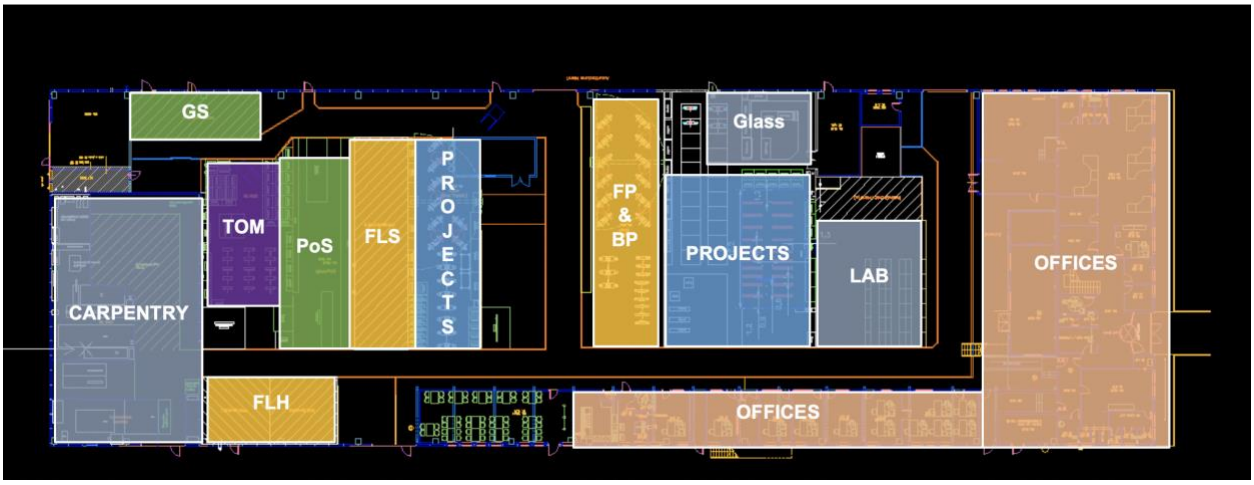

Figure 25, Visualization of the factory layout prior to 2019

The primary steps were to investigate the production processes, identify existing problems, and recognize potential improvements areas. It involved waste analysis, root cause analysis, and a value stream mapping to understand the current state and to set the focus and targets for the future state (see appendix 3). The Lean manager found that all areas of the production were already occupied, and thus, increasing the capacity would require improving the efficiency and the space utilization.

Another issue in the previous production was the significant amount of utilized space for their large volume batches, illustrated in figure 26. These were substantial hindrances for the advancements in the production plant in Lavis.

Figure 26, Illustration of previous production in batches

In accordance, significant wastes in the production lines were identified. Figure 27 demonstrates the value and non-value added processes in the production line for PoS. VA refers to the value-adding activities, NVA1 to the non-value adding activities which are necessary for the process, and NVA2 which are unnecessary waste that should be immediately eliminated. With only 10% of the production process being value adding, there was a great potential for reducing the cycle

time, and thus increasing the capacity. A breakdown of NVA2 activities, visualized in figure 28, identified wastes such as rework, transportation, and movement. Eliminating these wastes through a more efficient production layout, could have a decisive impact on the capacity and the ergonomics for the operators.

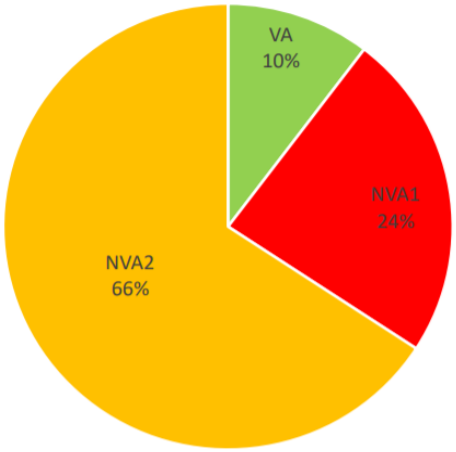

Figure 27, Distribution of VA and NVA activities for PoS

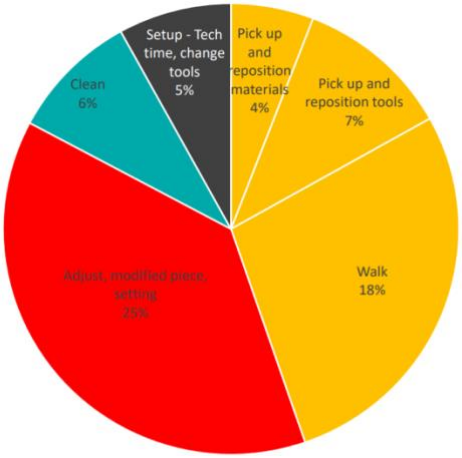

Figure 28, Breakdown of NVA2 activities for PoS

Gunnebo realized that it was necessary to reduce the batch production and minimize the areas used for production in order to be able to increase their capacity and reduce lead times. This is something that the customers value, and it has been the main drivers for the implementation of the Lean philosophy. The adoption of Lean would imply moving towards a single piece flow and advocate JIT and Jidoka for reducing inventories and the components in production lines, with an enhanced quality culture. This is similar to the company guidelines that were established from Gunnebo Operating System (GOS). The company believed that the greatest amount of lead time reduction could be achieved in the production, which resulted in an initial main focus towards spot improvements and design for manufacturing and assembly (DFMA). The DFMA was necessary in order to decrease the number of operations and limit the number of unique parts in the production. This enabled a shift towards more standardized product archetypes, with shared fixings and components within their product offerings.

The presence of the Lean manager in the shop-floor enabled the operators to discuss the change initiative and become familiar with the Lean philosophy. The Lean manager initiated general Lean training with the operator once there was free time, and minor spot improvements for one product line at a time. It was difficult to convince the blue-collars as most of them were used to the same working procedures for the last 15 years. The introduction of a one-piece flow was not well received initially, but the Lean manager was able to gain support by demonstrating significant improvements through time observations.

The early spot improvements regarded the Kaizen events which were focused on one production line each time. A Kaizen event for Gunnebo represents a limited time of maximum one week where

major physical changes are conducted. Contrary to Toyota's Kaizen events, they are rather extensive and the Kaizen events of Gunnebo could instead be regarded as transformations which have been planned thoroughly in advance. The first Kaizen event in the company was for SpeedStile FP, which result is visualized in figure 29. In general, this Kaizen event and the upcoming ones, involved general training in Lean, applying 5s, striving for one-piece flow by reducing batch sizes, Poka-Yoke by utilizing jigs to guide the process and implementing standard work. The event had a positive outcome with a 30% increase in capacity, and the provided short-term profits convinced the management team and operators in the Lean philosophy.

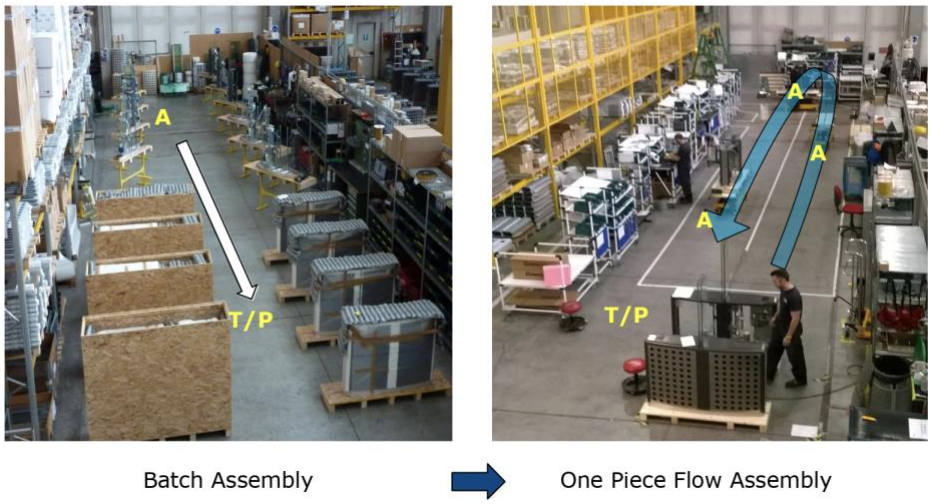

Figure 29, Demonstration of achieved change during the first Kaizen event at Gunnebo

After a Kaizen event, with standard work in place, it was possible to set a takt time and balance the production lines. In addition, visual boards were installed in the production line (see figure 30), presenting weekly performances related to security, quality, delivery, and cost. Within these four categories, relevant KPIs were shown, such as number of injuries, first-time failure rates, on time delivery and line efficiency. After a Kaizen event, the results were communicated in a Kaizen newspaper and a Lean session was dedicated in the quarterly "town hall" meetings.

Figure 30, Demonstration of installed visual boards

In 2018, two years after the Lean initiative, five Kaizen events had been held resulting in spot improvements for five product lines. After revising the progression of the Lean transformation, it was argued that the current approach would take too long time to implement over the whole production plant. The initial change strategy was thereby discarded, and a new Lean implementation strategy was set. Compared to previous changes, this Lean transformation project, called Golden Line, would improve two product lines at the same time, and significantly transform

the production layout. The Golden Line project was introduced to the management team in September 2018, and weekly management Lean meetings were initiated. This is when the change process extended outside the shop-floor, and the management involvement was intensified. The project therefore gained additional resources, with most of the middle managers being able to spend on average one day every week for Lean activities.

A few targets for the Golden Line were set prior to the implementation to measure the success of the transformation, as demonstrated in table 3. These targets were designed for FLH and FLS to ensure that the progressions made by the Golden Line were aligned to the original purpose and that the goal of the Lean implementation was fulfilled. This also enabled Gunnebo to visually demonstrate the improvements of the transformation to the organization.

Expected Results for FLS and FLH	**Target**
Improve capacity	25%
Improve efficiency of main assembly line	90%
Reduce percentage of orders started with missing parts [max %]	2%
Reduce test & packaging time	30%
Improved space utilization index (€/sqm)	No Target Set
Improved First Time Failure Rate [max %]	5%

Table 3, Expected results after the Golden Line implementation for FLS and FLH

Additionally, even if the focus was towards the material flow, some emphasis was set on improving the informative flow, mainly in the material & purchasing department. Previous operations had only been executed in excel, which was not considered to be sufficient in future production. This led to a decision to prepare for the implementation of an ERP, MRP and CRP system. This implementation had failed previously in the company which implied some initial disagreement, but training sessions were held, and a consultant was hired to coach the purchasing department for the implementation of the new system.

Another area subject to the change was the organizational structure. As can be seen in figure 31, several new roles were developed to support the Lean philosophy. A part of their traditional hierarchical structure was changed to emphasize a value-stream oriented organization with new roles such as the Value Stream Leader, Value Stream Planner, Mizusumashi and Warehouse Operator.

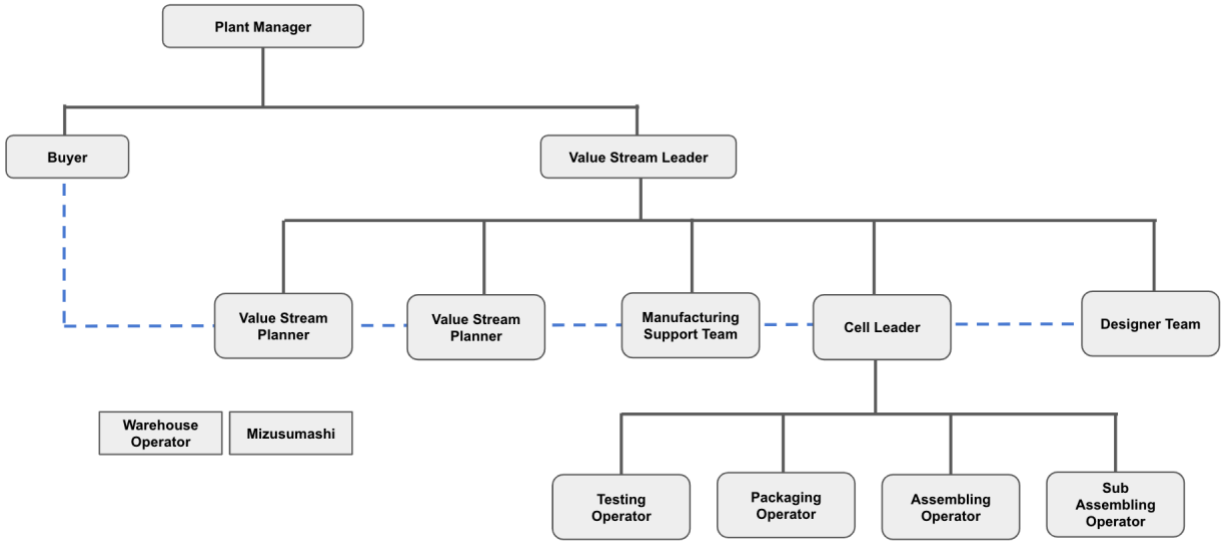

Figure 31, Planned new organizational chart

Starting with the Value Stream Leader, the new responsibilities regarded tasks such as creating a long-term production plan, a master schedule- and a capacity requirement plan. Furthermore, it is the Value Stream Leader's responsibility to guarantee that the product or service is delivered on time. Secondly, the Value Stream Planners are responsible for various types of maintenance of purchase & work orders, and item balance. They are also responsible for creating a short-term production plan and for the finished goods logistics. The Cell Leaders are now responsible for the quality of the line, respecting the takt time, conducting root cause analysis, training operators, and auditing 5S. One of the most important new roles is the Mizusumashi, further examined in chapter 4.3.3, which is responsible for replenishing the lines with the right components, in the right quality and quantity, at the right time. The Warehouse Operators are in charge of the incoming inspection to the allocation of stocks in the warehouse or the plant. The blue-collars in the production will be divided into four areas: Testing, Packaging, Main Assembly, and Sub-Assembly. Additionally, the operators will have a few additional responsibilities related to Lean, by assisting in 5S auditing, Kaizen events, and root cause analyses. The manufacturing support team, consisting of the Quality and Manufacturing engineers, will be in charge of the supplier development to enable the JIT production. This correlates with the buyer who develops the supply chain for the whole factory, including new suppliers to ensure that best practice adheres to all buyers for all lines. It should be noted that all of these new roles had the intention to be employed by using existing internal personnel. Currently, the entire value-stream organizational structure is not in place. However, the Mizusumashi, cell leaders and the division of operators are implemented, and a Value Stream Planner has been selected and developed.

4.3.2 First Quarter of 2019 - Preparing For The Golden Line Implementation

The key activities during the first quarter of 2019 can be visualized in figure 32. The first quarter of 2019 in this context refers to all operations from January until the implementation of the Golden Line in the last week of March.

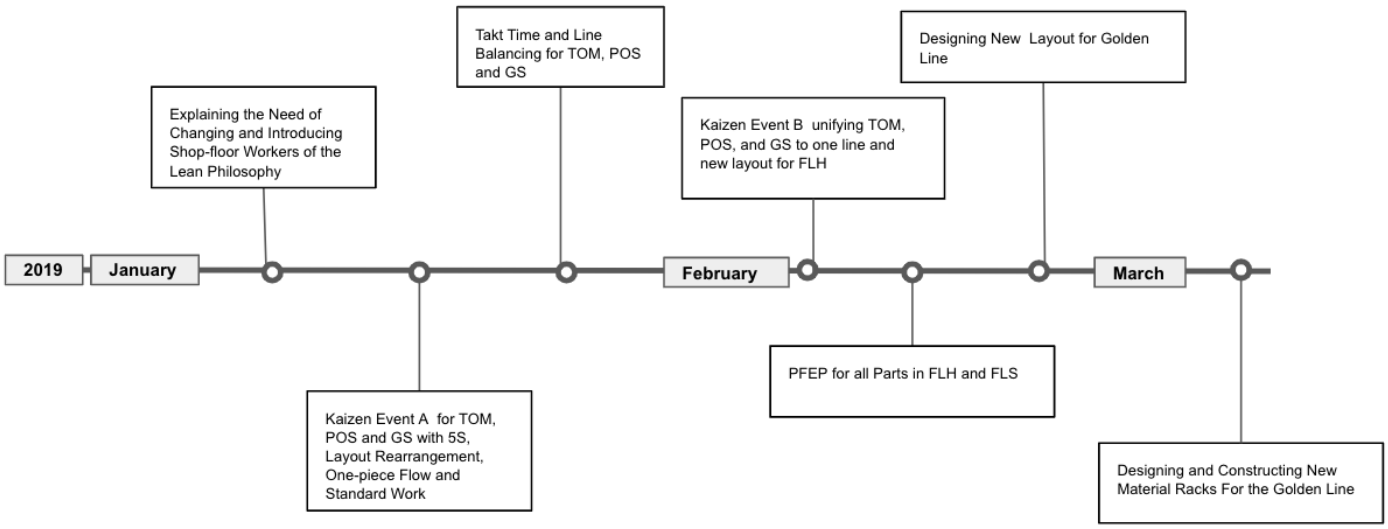

Figure 32, Demonstration of the key Lean activities during the first quarter of 2019

The first quarter of 2019 involved two extensive Kaizen events, A and B, with their main focus of preparing for the Golden Line in the second quarter. Discussed below is the progress and observations of all relevant activities that were conducted during this time period, divided under the two Kaizen events.

Kaizen event A

The first quarter of 2019 was initiated with an extensive Kaizen event, involving three product lines: TOM, PoS, and GS. In comparison to previous events, this event was made primarily to assist in the creation of the Golden Line and was therefore only a temporary rearrangement. The temporary layout enabled free space for Lean activities related to the Golden Line, see figure 33.

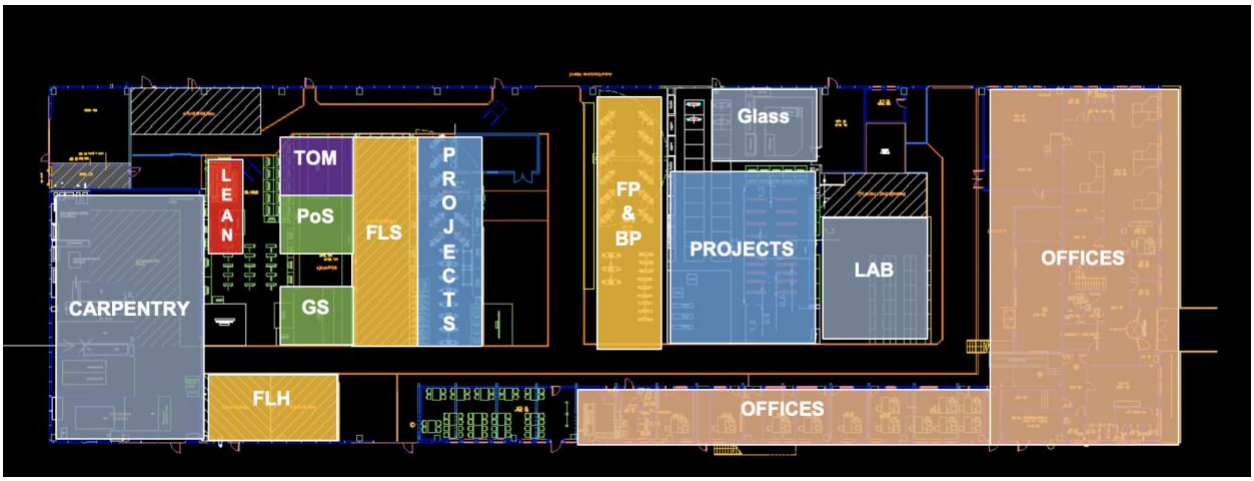

Figure 33, Visualization of factory layout after Kaizen event A

As for the previous Kaizen events at Gunnebo, it started with general training in Lean for the operators. The Lean manager explained the basic concept and argued for the importance of change within the company. Specific Lean tools that would be utilized were also described and a process map (visualized in figure 34) was used to facilitate the new design of the line. The meeting enabled a discussion between the operators and managers, where eventual disagreements or questions could be raised. This room was the place for all Lean meetings and administrative activities, where a visual "scrum board" (demonstrated in figure 35) was utilized to visualize the progress, responsibilities and defined tasks.

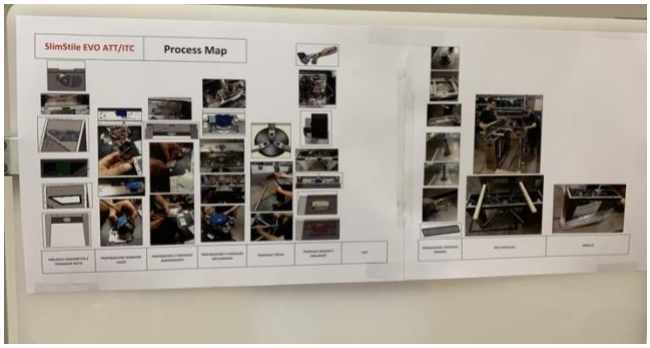

Figure 34, Illustration of Gunnebo's process map

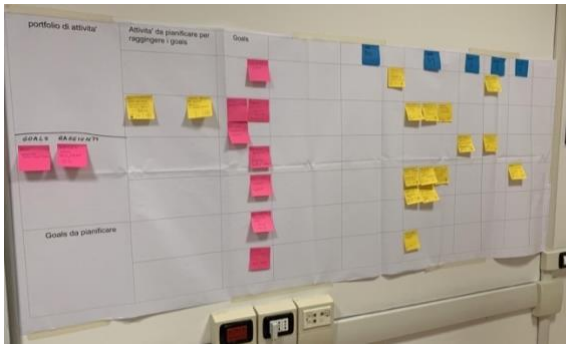

Figure 35, Illustration of utilized "scrum board" for planning

The Kaizen event that started in the beginning of January, was initiated with the removal of all objects, followed by cleaning. Figure 36 and 37 demonstrate the change in space, before and after the Kaizen event. The established Lean activity area (marked red in figure 33 & 37) enabled the company to have a dedicated area for constructing racks on wheels to facilitate the second Kaizen event that was held during the end of the first quarter. Having an improvement area located in the shop-floor, close to the production lines, enabled the operators to see the progress of the activities while working.

Figure 36, the state of area before the Kaizen event

Figure 37, The gained space after the Kaizen event

Several new racks for TOM were needed in order to minimize the line to support for the Golden Line. The benefit with building new racks was that they could be tailored specifically for the subprocess they belonged to, which meant that they could have a minimalistic design to support a 5S approach, leaving no room for non-essential tools or materials. Furthermore, every rack was built with wheels to allow for an easy reallocation for the Golden Line and other future rearrangements.

This Kaizen event also included the application of 5S and standard work for the TOM, PoS, and GS. Each operator working in the production line of TOM got to present, step-by-step how the product was processed, from fetching the customer order to when the product was ready to be delivered. Afterward, a best-practice was agreed upon among the operators and managers, which was documented and visualized on a piece of cardboard that was placed in the line. After the best practice had been decided, all tools and materials were located to follow the production sequence of the best practice and tape was put on the floor to define a specific location for each rack. Furthermore, during the repositioning of the components and tools, a 5S sorting activity took place where the operators were asked to first remove all irrelevant tools, then further sort by identifying which of these tools that were used on a weekly basis. Figure 38 demonstrates before and after a conducted 5S activity in the production line for TOM.

Figure 38, Demonstration the result of a 5S activity

After the first Kaizen event was finished, observational time studies were conducted on the TOM line. This was necessary in order to balance the line and to understand if the process had been improved. The observational time studies after the Kaizen suggested a decrease of cycle time by 64,3%, which relates to the removal of the previous significant wastes primarily regarding movement and transportations.

Kaizen Event B

Kaizen event B was held one and a half month after the Kaizen event A, where the production area once again was rearranged to prepare for the Golden Line. As visualized in figure 39, the TOM, PoS, and GS were unified to a single production line and took the previous location of FLH. Even though their respective area got reduced considerably with 75%, the efficiency of the lines still maintained the improved capacity of 64,3%.

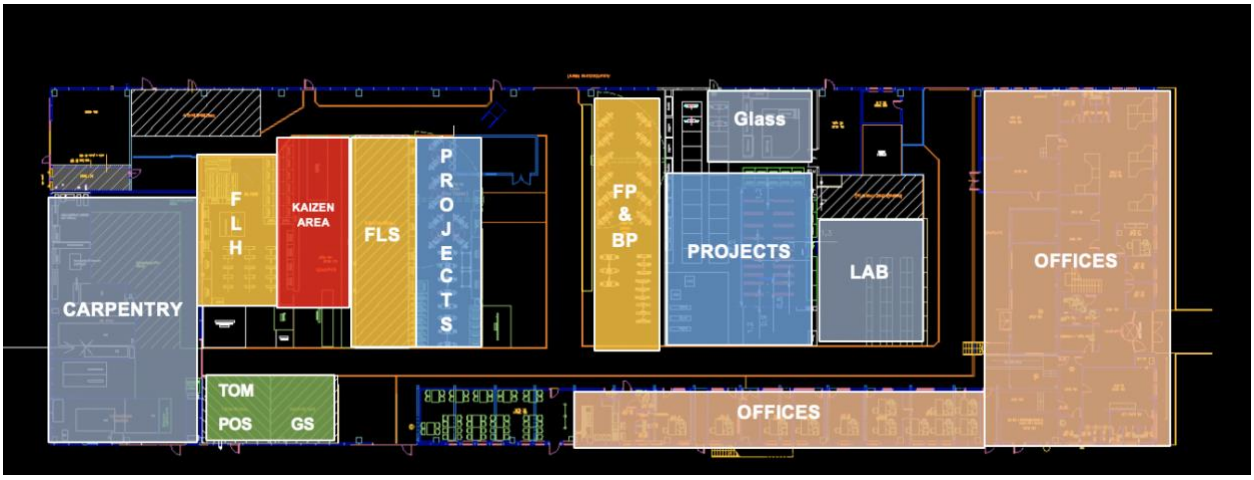

Figure 39, Representation of the factory layout during the first quarter of 2019

The unified layout in practice can be seen in figure 40, where TOM (green area) and POS (cyan area) represents two straight lines, in accordance with the Golden Line production direction. In addition, the GS (purple area) is located in the bottom left corner, in order to be supported by the lift crane.

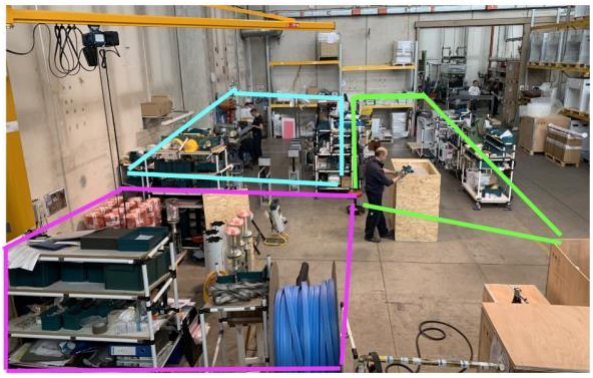

Figure 40, Illustration of the unified area consisting of TOM, PoS and GS

The compressed area for TOM, PoS, and GS generated space for a more extensive temporary improvement area, designated to the construction of all the new racks for FLS and FLH. With a PFEP (Plan For Every Part) that was established for the production lines FLH and FLS, made it possible to precisely plan and design the new layout and all necessary material racks. The new racks were constructed during March to support the future replenishment system that would be utilized for the Golden Line, which is explained more in detail in the next sub-chapter. The temporary improvement area was also a way to demonstrate the ongoing improvement efforts and give the operators an idea of what was going to change. This made it possible for them to be involved, ask questions and give suggestions in the construction of the racks.

4.3.3 Second Quarter of 2019 - Implementing The Golden Line

The key activities during the implementation of the Golden Line and continuous improvements during the second quarter of 2019 can be visualized in figure 41. This sub-chapter aims to describe changes in the material and informative flow during the second quarter of 2019. In addition, this chapter is concluded with the performance of the predetermined targets of the Lean implementation.

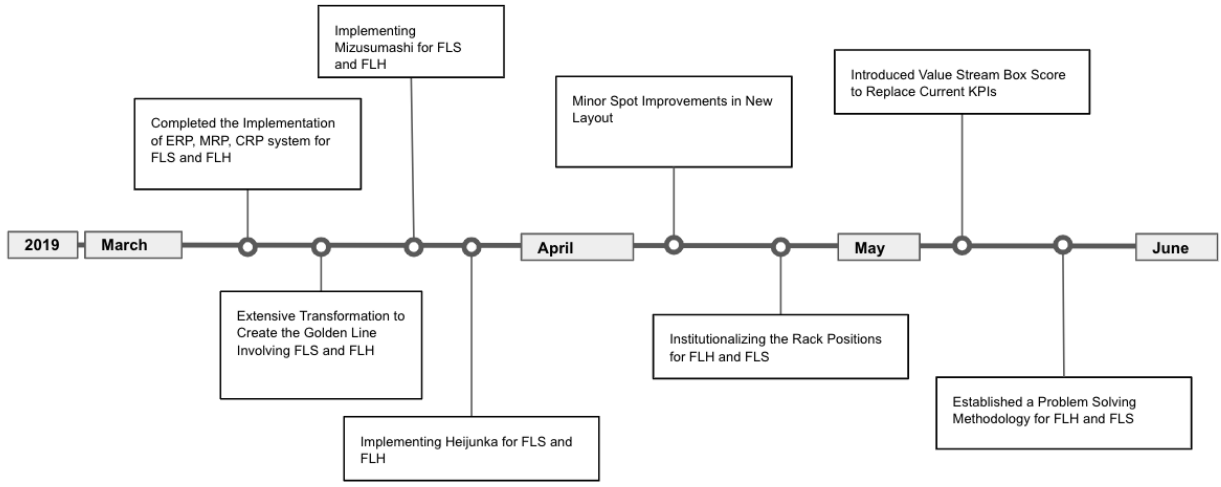

Figure 41, Demonstration of the key Lean activities during the second quarter of 2019

Changes in Material Flow

When all the preparatory activities for the relayout were completed, the extensive Kaizen event to implement the new production lines took place. As presented in figure 42, the Kaizen area is now removed and the main-assembly for FLH and FLS are positioned horizontally, making the direction of the material flow the same for both production lines. In addition, new areas have been created for Mizusumashi, sub-assembly, testing, and packaging. The following sub-chapter aims to describe the new concepts and the reasoning behind actions supporting the Golden Line, which were set in place during the second quarter of 2019.

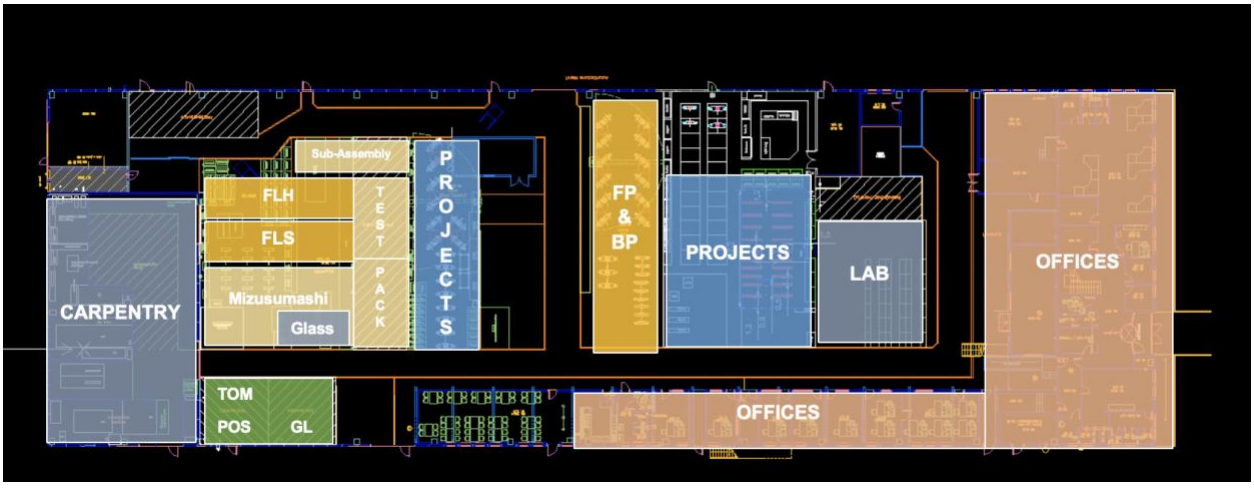

Figure 42, Representation of the factory layout after the Golden Line implementation

Main Assembly Lines

The new lines in place are illustrated in figure 43, with left referring to the production of FLS and the right side referring to FLH. This is where the main assembly process is executed, and the other functions that are necessary to the production, i.e. sub-assembly, replenishment, testing, and packaging, are moved outside of the main assembly line.

Figure 43, Illustration of the new productions lines of the Golden Line

The intention with the division of work tasks was to make the operators experts in the different areas, by limiting the number of different types of operations.

Replenishment Area

The replenishment area is dedicated to the Mizusumashi as inventory storage, which is visualized in figure 44. All components that are used in the FLH and FLS production are stored in this area, adjacent to the production lines. This allows for the Mizusumashi to easily restock the production lines when given a Kanban-signal.

Previously, the operators managed all material replenishments themselves which required a significant amount of time for searching, walking and retrieving the correct components. The previous way of working also encouraged producing in batches of large lot sizes to minimize the walking distances.

Figure 44, Visualization of the new replenishment area

Sub-Assembly Area

A sub-assembly area was created for operations that were possible to perform externally, i.e. outside the main assembly line. For instance, these operations refer to preparing kits for the kit racks in the main assembly, which involves processing on the top lids. Other operations can be to prepare the mechanisms, that are then stored in a supermarket, which the Mizusumashi moves to the line when given a signal. Two sub-assembly areas for FLH can be identified in figure 45.

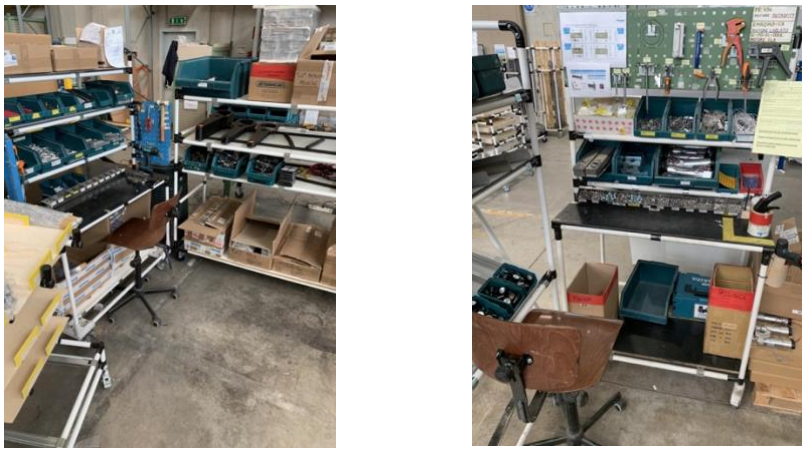

Figure 45, Representation of two sub-assembly areas for FLH

Testing & Packaging Area

A shared testing and packaging area were created for the FLH and FLS lines, which is visualized in figure 46. This area made it possible to always keep the testing activities ongoing, which then gets transported to the connected packaging area.

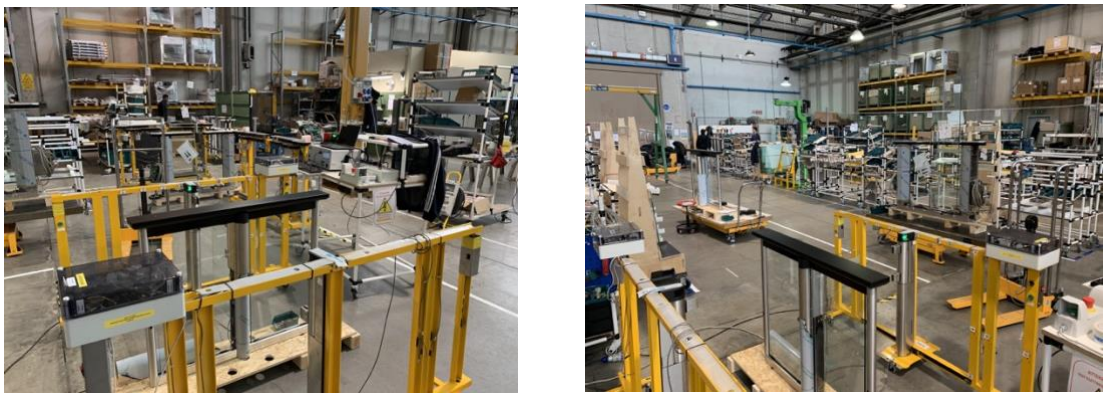

Figure 46, Representation of the testing area

Mizusumashi

A new role in the production plant was identified as necessary to increase the capacity in the production. The Mizusumashi carries the responsibility of replenishing the lines with the right material, in the right quality at the right time. This was enabled by creating an area where all of the materials are stored and then regularly delivered to the production lines when given a signal to replenish. The FLS and FLH utilized three types of racks, i.e. supermarkets, double-racks, and workbenches. The construction of these racks facilitated a milk run for the Mizusumashi and enabled the rearrangement for Golden Line.

Kitting

The double-rack method was applied for large and heavy components that did not fit inside a bin, and for components that are order-specific. This method implied creating two identical racks (exemplified in figure 47), one that was used in the production line, and the other being stored behind. When the first rack is empty, the Mizusumashi is given a signal to gather it and place the second replenished rack in the production line, followed by a repeating process.

Figure 47, Demonstration of the double-rack method

Another branch of the double-rack concept is the tray-racks, which are demonstrated in figure 48. For these racks, trays are kitted in the sub-assembly for the main-assembly line with components that will be used for a specific build order.

Figure 48, Demonstration of the tray-racks

Supermarket

The double-bin method is used for smaller components that fit into a bin. Once a bin has been depleted, the operator will put the bin in the bottom level of the rack, which sends a signal to the Mizusumashi to collect and replenish with a new bin of components. A demonstration of the double-bin method can be shown in figure 49, and figure 50 represents a supermarket that is used in the main assembly line for FLS.

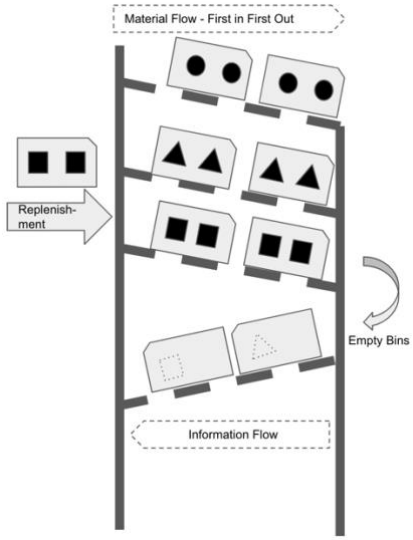

Figure 49, Demonstration of the double-bin method.

Figure 50, Physical representation of the double-bin method

Bin Labels

To support the Mizusumashi and the informative flow there was a need for a new system for the bin labels. The labels were divided into two categories, front and back labels. The front labels were designed to contain only essential information for the operators, which includes part number and part description, see figure 51. The back label was designed to simplify the replenishment process which was achieved by including a barcode containing part number and quantity for the new MRP system. In addition, the part number, part description, rack location, quantity, an image of the component, stock area, and the bin ID, are included in the label as demonstrated in figure 52.

Figure 51, Illustration of front bin label

Figure 52, Illustration of back bin label

Institutionalizing the New Layout

After all of the racks and workbenches were put in place, the Mizusumashi function was tried. Once confident that the replenishment system would work, the two production lines were tested. The trial showed great success and therefore the new layout was set by color coding the floor with tape (visualized in figure 53), which demonstrated the rack and its category. In addition, the floor got marked with the corresponding rack ID to further emphasize its fixed position.

Figure 53, Demonstration of fixed rack positions

Changes in Informative Flow

The importance of changing the informative flow was also recognized which has led to the implementation of an ERP, MRP, and CRP system and a new way of scheduling production. Interviews confirmed that the emphasis has been on improving manufacturing areas, and less on the non-manufacturing areas. However, it will be important to further improve the non-manufacturing areas in accordance with Lean, as these will determine the success in the production. Interviews revealed that there could be problems in the informative flow for future Lean progress due to the unexpected projects that do not follow standard price list or procedures.

Heijunka

For the production scheduling, an adaptation of the Heijunka methodology was used. Illustrated in figure 54 is the Heijunka used for the FLS (left side) and FLH (right side). The principle is to provide a simple, visual illustration of the demand, with simplified and improved build instructions for the operators, and a picking list for the Mizusumashi. The Heijunka works by having five zones, where every zone consists of four build instructions, i.e. customer orders. The build instructions start at the 1st zone and processed down via gravity to later finish in the 5th zone. In practice, the Heijunka is read from the right to left to follow the rules of pull production.

Figure 54, Demonstration of the Heijunka Scheduling

When the company gets a customer order, the purchasing department attaches the build instructions in the 1st zone. When the 2nd zone is empty, the build card slides down to the 2nd stage, and the Mizusumashi starts to prepare the sub-assembly lines with the needed components for the kitting process. In the 3rd zone, the sub-assemblies initiate the kitting procedure for the main assembly. In the 4th zone, the Mizusumashi prepares the main assembly with the order specific items. Finally, arriving in the 5th zone the operators are given the signal to initiate the production, and once the product is finished, the build instruction is removed, and the next order will slide down. Consequently, the Mizusumashi always prepares the main- and sub-assembly lines with the correct material, one zone in advance.

Implementation of ERP System

With all purchasing operations previously executed and documented through an excel spreadsheet a more efficient informative flow was needed, to support the operational flow and the Lean philosophy. Training in ERP has been ongoing since autumn 2018, with the intention to fulfill the transition during the Golden Line implementation at the end of March. This implied adapting an MRP for the inventory and purchasing management and a CRP for implementation for managing capacity of the main assembly lines. The Master Production Scheduling (MPS) represents the CRP to understand when and how many of each product needs to be produced.

Figure 55 illustrates how the Heijunka is integrated with the production and controlled by the capacity planning made in the MPS. The overall motivation behind the ERP system is that it improves the control over their inventories, stock levels and to reduce the overall complexity of the informative flow. This system, compared to excel, also allows the purchasing department to act more proactively and effectively, where orders can be customized according to the demand and lead times, which will support the just-in-time philosophy.

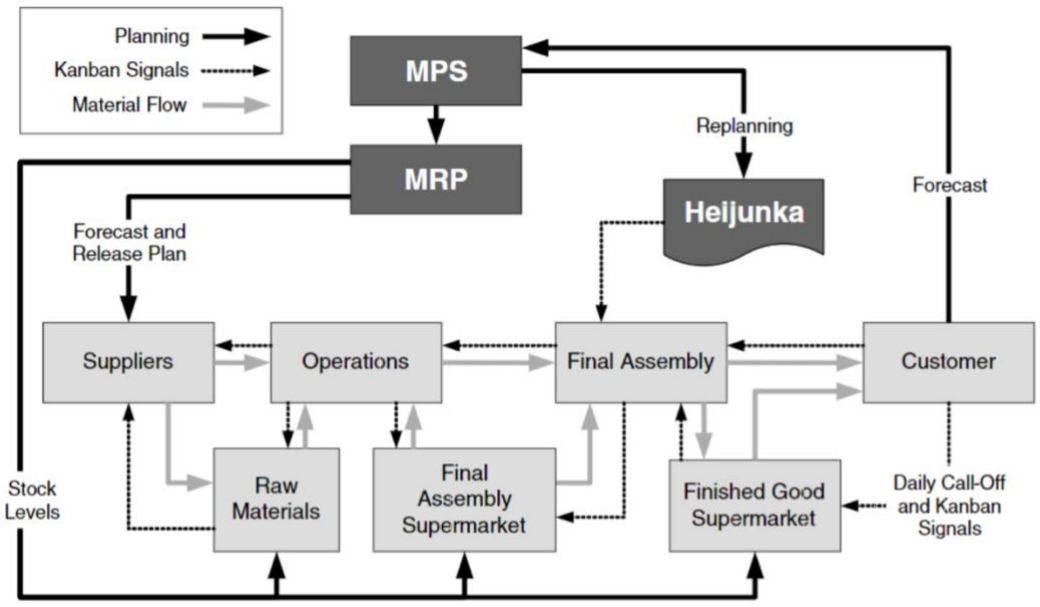

Figure 55, Representation of the integration of ERP

During the first quarter of 2019, the new informative flow was partially implemented, with a few products being tested in order to learn how to use it effectively. The new ERP system was supposed to be fully settled after the Golden Line implementation, but it was noted that it still needed more time to mature. In addition, other tasks and issues had higher priority and the speed of the transitioning thereof had some minor delays.

Key Performance Indicator

Currently, no new KPIs have been adopted, and the previously mentioned KPIs, i.e. number of injuries, first-time failure rates, on-time delivery, and line efficiency, are still measured. However, in order to support for correct Lean behaviors and measure the Lean effects, a value stream box score (VSBS) got implemented in April 2019. In its transitioning, the company sought to measure both the previous KPIs and the newly established in VSBS, where eventually the old KPIs get abandoned.

The purpose of the VSBS is to shift the focus of the previous KPIs which supports large lot sizes and mass production, to KPIs which instead supports the Lean philosophy. The VSBS contains the following areas of metrics: Value Stream Performance, Value Stream Productivity, and financial measurements. Due to confidentiality issues, the full box score will not be included. However, a few examples of how one can measure value stream performance are Throughput time, on-time delivery, and Flow index. For Value Stream Productivity, one can measure Waste of Labor Time, % Productive Time, and Non-Productive Time Planned. Lastly, the Financial measurements relate to the Value Stream Revenue, Value Stream Total Cost, and Cost of Inventory.

A3 Form

Multiple minor issues were observed in the production lines which interrupted the production flow. These were quickly taken care of but the consistently occurring 5-15 minute problems were not documented. To properly document these and remove the time-consuming fire-fighting activities, an A3 problem solving approach was implemented. This resulted in a simple document in the product lines where the operators were instructed to take a quick note every time a small problem occurred. These problems were thereafter discussed in the next day, following an A3-page (see appendices 4 and 5) where a problem description, a target state, a root-cause analysis, immediate actions, preventative measures and a plan for how to validate the improvement was determined. In addition, a follow-up on the issue was established to ensure that it has been solved correctly and will not occur in the future. On the backside of the A3-page, a guide on how to properly fill all of these areas was included to allow anyone with or without experience to fill the form.

Achieved Results

The results after the implementation for the Golden Line for FLS and FLH can be seen in table 4. All results are based on data collected from April 2019 which are calculated against previous production averages. Significant improvements can be demonstrated, especially in the production line for FLS where all predetermined targets were exceeded. FLH barely missed on achieving the targets for improved capacity, improved efficiency, and reduced test & packaging time. The missed targets can be traced to optimistic expectations and the fact that FLH already has been improved by two previous Kaizen events. Despite this, a capacity improvement of 22% and improved space utilization by 20% is still a massive improvement aligned with the overall purpose of the Lean transformation. In addition, combining the results of FLH and FLS, i.e. the products of the Golden Line, would demonstrate that all set targets were reached.

Expected Results for FLS and FLH	**Target**	**Result FLS**	**Result FLH**
Improve capacity	25%	30%	22%
Improve efficiency of main assembly line	90%	95%	88%
Reduce percentage of orders started with missing parts [max %]	2%	0%	0%
Reduce test & packaging time	30%	33%	25%
Improved space utilization index (€/sqm)	No Target Set	25%	20%
Improved First Time Failure Rate [max %]	5%	4,3%	3,4%

Table 4, Expected Results of the Golden Line matched against the results

4.3.4 Future State of the Lean Transformation

The key activities in the future for sustaining and developing the Lean philosophy can be visualized in figure 56. This sub-chapter intends to present the plans relevant to the Lean initiative that is either only partially implemented and requires maintenance, or concepts that need to be implemented but still remains as a theoretical concept.

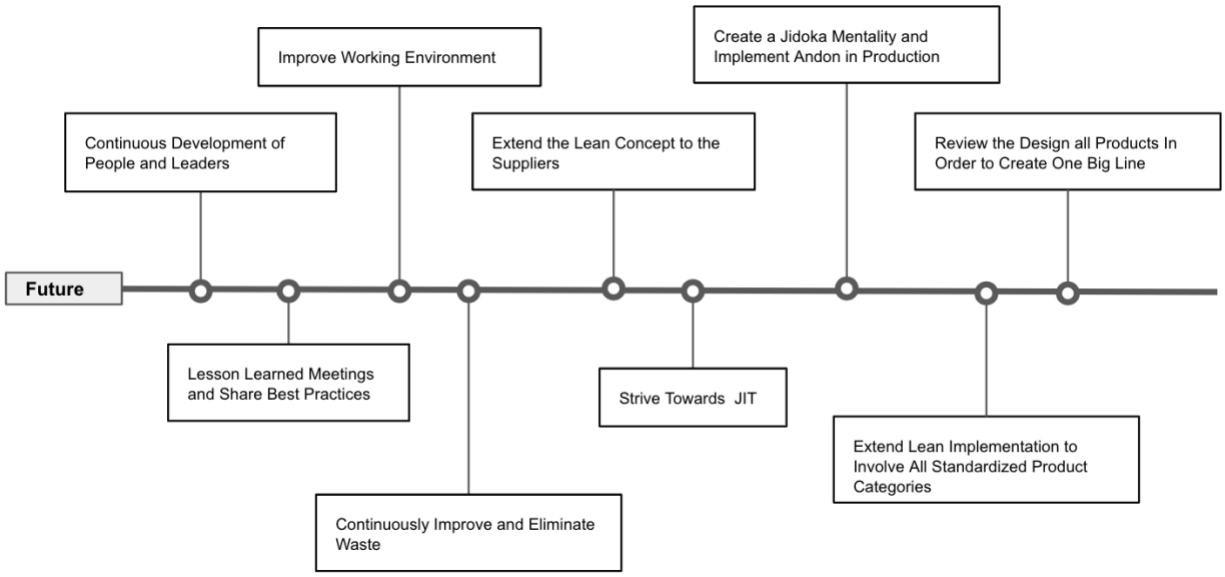

Figure 56, Demonstration of the key Lean activities for the future state of the Lean Transformation

It was stressed in the interviews that the employees understand that the Lean transformation is a lengthy process and that they have not reached a final state by far. The upcoming years aims to continuously improve the Lean culture, put more emphasis towards the soft practices, and extend the Lean mentality to suppliers. Proven success of this Lean initiative is paramount for the company, as Gunnebo aims to be the pioneers in the market and role models within Entrance Control.

Sustaining the Change

The white- and blue-collars were aware that the transformation was not finished after the Golden Line implementation, and in fact, would require even more emphasis afterwards. However, it was notable that there initially was less attention towards the Lean transformation past the Golden Line implementation. It is natural to feel that the change is completed after a significant transformation event, which demonstrates the need of continuously updating the goals and setting new ones to strive for. Furthermore, it requires extensive communication to ensure that everyone is motivated to continuously improve and aligned with the new agenda.

With the Golden Line in place, it is important that the changed behaviors are sustained. It is vital that the change continues to be a capacity improvement without compromising the working

environment for the operators. Therefore, more emphasis in the future will be put towards improving the working environment. The change already resulted in better ergonomics and less movement, and the implementation of additional lift cranes and new tools seeks to further support the production process. Additionally, the company aims to paint the floors white, to improve the lighting and overall cleanliness in the production plant.

Moreover, the company seeks to continue with training sessions in Lean to develop the people and Leaders. Training sessions are scheduled in the second and third quarter of 2019, and "lesson learned meetings" will be held to review the change process and share best practices.

Supplier Development

The supplier relationships are vital in succeeding with the Lean initiative as they play an important role in the value stream. The case company strives to improve the relations with suppliers and implement a Lean section in their audits to support the Just-In-Time production. However, due to the size of the company and purchasing orders, they are often not considered as a key customer which makes their bargaining power relatively low. Hence, finding the right suppliers and establishing strong relationships requires significant emphasis as it provides means to reduce the stock, limit controls and improve quality. It should be noted that some initial efforts have been made and that the importance of this principle has been recognized by the company as the material cost is significantly higher compared to the labor costs. In the future, the goal is to integrate the suppliers into the internal informative flow to instantly send Kanban signals throughout the supply chain to lower the lead times and support a one-piece flow.

Continuously Improve

The Lean culture can be improved and sustained by creating a continuous improvement mindset at all levels of the organization. The company has realized that they need to interrupt the flow when detecting deviations from the standard, with the aim to investigate the root causes to prevent further interruptions. This requires an incremental change in people's behaviors as it is considered to match neither the national nor the current company culture. It is not the tools that are important but rather the mindset of devoting sufficient resources and fixing problems immediately when they occur. By implementing Andon with a Jidoka mentality and establishing routines for PDCA, it is possible to create a standardized procedure of dealing with issues directly and documenting the changes to sustain and freeze the improved state. Jidoka is considered to be the last and most important step of the transformation. The goal is to make the line leaders responsible for leading these improvement activities themselves with the assistance of the operators. In addition, further 5S efforts can be conducted in the lines to sustain the physical state of the production lines by implementing routines for how to clean and store each item in the lines.

Additionally, the Golden Line implementation resulted in two product lines being improved according to the Lean Philosophy. The Lean transformation will in the future strive to include all

eight product categories that are produced in the production plant, with the Golden Line implementation as a reference. After achieving this state, which is recognized to be a lengthy process, there are plans to review the design of all products and establish a common product architecture that can enable one big line, producing all their product offerings.

4.4 Challenges in the Lean Transformation

This chapter aims to describe the change management aspects of the Lean implementation. The data is acquired through interviews and observations of the environment, meetings, and discussions.

4.4.1 Challenges During the Initial Phase of the Lean Transformation

When the Lean manager got appointed in 2016, heavy emphasis was put towards shop-floor improvements. In fact, during the first two years, all activities were at a Gemba-level which made the operators perceive the change as their own and not something that they were being forced upon. Approaching one product line at a time enabled the Lean manager to focus on a smaller set of operators, which could be provided with general training in Lean. The blue-collars were not convinced that the one-piece flow would improve the production speed, and timings between batch flow and one-piece flow were used to demonstrate the effects. The Kaizen events that were held before 2018 were successful individually, but the pace of the transformation was considered to be too slow.

In September 2018 the management team started with weekly Lean meetings which continued over the full Golden Line implementation period. In addition, a larger presentation was held to the management to clarify the purpose, goal, and vision with the new transformation project, the Golden Line. However, interviews stated that the initial communication was not clear regarding the delegation of tasks for the respective departments, which resulted in the majority not being aware of what was needed to change. After a few months into the transformation, a more well-defined plan was established with clear tasks and responsibilities aligned to the company strategy. The case company realized early that they would have to put additional efforts in involving the blue-collars as the change would have the most impact in the shop-floor. Therefore, the white-collars increased their presence in the production and informed the blue-collars that the company was in need of changing. This led to an investigation of what could be improved in the shop-floor, with the means of creating improvements that were mutually beneficial between white- and blue-collars.

In addition to the weekly meetings, there were quarterly “town-hall” meetings where everyone in the organization was requested to join. These meetings regarded the production more in general but also included information about the Lean progress. Even though they had these communication sessions, several managers perceived that the communication between the departments was lacking and that they were not fully updated. However, the change drivers had

sufficient information to know whether the departments could achieve their goals or not. Regarding the communication to the operators, which were not present in the weekly Lean meetings, they claimed to not be updated with the progress of the other departments and they would have preferred more.

Interviews revealed that the change initiative, like any other organizational transformation, initially resulted in anxiety and stress among the employees. The interviews also stated that changing the behaviors and mentality of the people was a major challenge, as everyone had to balance it with their ordinary day-to-day activities. Moreover, it required a high degree of flexibility and determination in approaching and organizing the new projects to follow the new philosophy. The change mentality was varying, with some being more ready to change than others. In order to convince potential change drivers for each department, the company visited other Lean plants to inspire and motivate for the transformation. A comment from the interviews stated that the current positive company growth affected the change mentality since it was argued that there was no need of changing. However, the market grew faster than the company, and essentially the company was losing market shares due to current capacity and lead times. The change management required a heavy amount of effort, and it was important to stress that the Lean transformation was only for the better and that it would not lead to any layoffs or increased workload. The purpose of the Lean change was therefore clarified to only improve the current state and the quality of working by improving the space utilization and the ergonomics. From there, the company had to manage all setbacks that would occur, with successful small spot improvements slowly increasing the change acceptance. The communication of the purpose can be argued to be successful as the company never faced any significant resistance from operators or their unions. After the proven success of the spot improvements, it was possible, by measuring and presenting the enhancements, to convince both blue- and white-collars to change and adopt the Lean philosophy. Interviews revealed that the proven early success, lead to the majority of the employees being ready to change and prepared to overcome any occurring setbacks to become a Lean organization.

4.4.2 Challenges during the Implementation of the Golden Line Project

With the proven success of the previous spot improvements, the organization was ready for greater changes with an aligned goal. According to interviews, these early gains were a decisive factor in the progression of the Lean transformation, as setbacks and challenges were worth overcoming for achieving the potential future state that is possible with a Lean philosophy.

The first intention was to enable space for the Lean transformation project, by going from a large batch-flow to a one-piece flow for all the production lines. The interviews acknowledged that the Lean training was not provided for all the operators, and therefore everyone was not completely convinced of the one-piece flow. It was noted that actions deviated from the wanted behaviors, see figure 57, which required attention from management. After discussion with the blue-collars, it was argued that the lines still contained lots of wastes connected to transportation and movement,

which motivated for this type of batch production. In addition, the planning and the execution of the change were argued to be too fast, and thereof some product variants were not considered in the design of the production lines. By listening to these concerns, an agreement was made to accept smaller batches to cover one customer order and change the inventory location to simplify the material handling for the operators. Once these modifications were online, these types of behaviors were step-by-step removed, and a small lot-size production could be maintained.

Figure 57, Demonstration of reverted behaviors in production

Changing the mindset and behaviors of people are one of the biggest challenges in organizational transformations. Due to low employee turnover, it becomes even more difficult because people have worked in the same patterns over the past 15 years. This was a prerequisite for the blue-collars, and in theory, the managers expected this to be the most difficult to change. However, given the results post the implementation of the Golden Line, it was noted that the operators were changing the most and with less resistance than the white-collars. According to interviews, the white-collars were not aware of the extent to which they were required to change and therefore more resistance was faced. It was considered to be a critical moment to convince them that this is an organizational change that everyone will be affected of.

Throughout the change, extensive management involvement was observed. Every Kaizen event was led by the Lean Manager and Project Leader, with teams consisting of blue-collars for the affected lines and other available white-collars. In addition, some white-collars spent time every day in the production lines to discuss the progress and eventual issues regarding the change. The management involvement during these changes made the progress a team effort, and not something that the operators were being forced upon. However, resistance and misunderstandings, due to lack of communication between white-collars, led to defying the preferred behaviors, see figure 58, where freed up space was used for storage purposes. This led to blocked passages and limited access to components which resulted in additional work for the operators. The removal of these issues was possible through discussions in the weekly Lean meetings, and by defining areas that had to be clear for Lean activities.

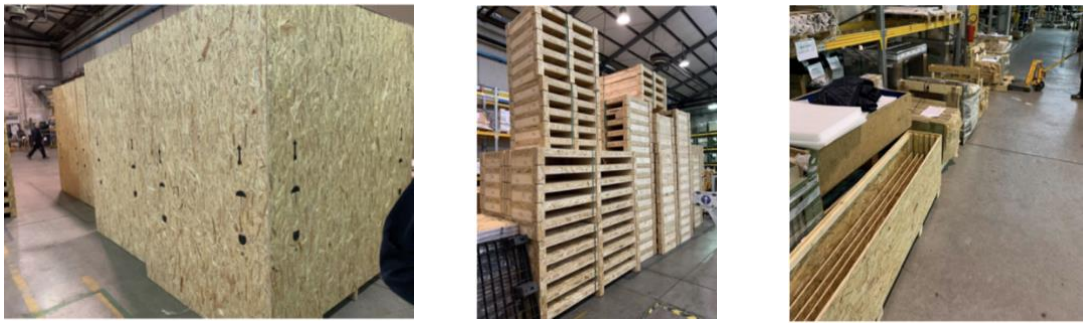

Figure 58, Visualization of freed up space being used for storage purpose

The insufficient communication was also noticed among the blue-collars, which lacked information in the new way of working and were confused about what was to be expected from them. Hence, some operators still believed that the workload would increase and that the change was primarily about reducing costs. Additionally, some of the newly implemented tools had not been properly introduced and communicated to all operators, and some blue-collars did not understand how they functioned or how they could benefit from it. Moreover, the division of work with operators trained for specific roles made the production line more sensitive to the absence of these experts. There are plans to include work rotation and thereby develop the skills of the blue-collars to be available for multiple stations. However, it does not have the highest priority as there are no significant repetitive movements for the different operations.

After the Golden Line was implemented, they held a celebration activity where everyone got rewarded and were presented with the physical changes where all of the new concepts were explained. Currently, there are no plans to introduce any financial incentives, like bonuses, to promote engagement in Lean efforts. This is partially because of the local regulations which constrain how bonuses are allowed to be introduced. In addition, it is important that they do not favor specific workers, and thereby risking the involvement of unions. Not having any financial incentives could be a challenge in the continuing Lean transformation, once more extensive changes will occur. However, an interesting comment from the interviews was that the introduction of new Lean roles and the additional training allowed for new career opportunities which were seen as great incentives to be involved. This encouraged employees to engage in the Lean concept to expand their expertise in the field. Additionally, the interviews confirmed that the employees want to learn more about Lean and expand their expertise within the area. Therefore, several training sessions have been scheduled in the near future, which are likely to continue as the Lean culture improves.

5. Analysis

The analysis intends to connect the established theories with the results of the case study. The analysis will initially present the change management during the Lean transformation at Gunnebo, which is linked to Lewin's basic change model, Kotter's 8-step model and Likers 4P-model. Furthermore, the success of Gunnebo's Lean Transformation is discussed in relation to the determined Six Key Constructs of successful Lean improvement by Sisson and Elshennawy, which is supported by the 10 dimensions of a Lean system by Shah and Ward. Lastly, the analysis is concluded with a breakdown of the main challenges for Gunnebo during this Lean transformation period.

5.1 Change Management during the Lean Transformation at Gunnebo

The sequence of the Lean transformation at Gunnebo can be described in correlation with Lewin's change model, Kotter's 8-step model and Liker's 4P-model. The sequencing is divided according to the empirical chapter, i.e. Initial Phase, First Quarter of 2019, Second Quarter of 2019 and Future State. Additionally, the chapter is concluded with a suggested holistic framework for a Lean transformation in relation to the aforementioned theories. It should be noted that the transformation at Gunnebo can be argued to consist of several small unfreeze-change-refreeze cycles, where Kotter's 4th-8th steps has been repeated. However, for the ease of understanding the overall transformation, a broader holistic view has been applied which describes the transformation as a single large change cycle.

5.1.1 Initial phase of the Lean implementation

As visualized in figure 59, the initial steps of the transformation, the unfreeze phase, had a heavy emphasis towards understanding the need of changing and creating a vision with a desired future state. This can be connected to the first three steps of Kotter's 8-step model, i.e. *Establishing a Sense of Urgency, Forming a Powerful Guiding Coalition* and *Creating a Vision*. Additionally, considering the foundation of Liker's 4P-model, a long-term vision was created with an initial focus only at a Gemba level.

Gunnebo moved to the fourth step in Kotter's model, *Communicating the Vision*, once a value stream mapping was conducted and a Design for Manufacturing and Assembly (DFMA) was initiated. This step was the beginning of the change phase in Lewin's Change Model, which continued to emphasize the need of changing and explaining the benefits of the Lean philosophy. As the initial focus was at Gemba level, it was mainly presented towards the blue-collars, and more specifically the operators that would be affected by a Kaizen event. These blue-collars also received general training in Lean in correlation to these events. This transitioned the change into the fifth and sixth step of Kotter's model, i.e. *Empowering Others to Act on the Vision* and *Planning for and Creating Short-Term Wins*. As discussed in the empirical chapter, these early Kaizen events were successful and provided the necessary short-term gains of increased capacity and improved space utilization, to convince the employees of the Lean philosophy. This state of change was also present during 2017 and 2018, which was characterized by minor spot

improvements for a specific production line, without an aligned direction or long-term vision. Contrary to Liker's 4P-model, a long-term vision should always decide the company's actions, even at the expense of short-term profits. However, considering this Lean transformation, these necessary short-term wins to gain a critical mass of support, as stressed by (Beer & Nohria, 2000), is of vital importance and needed in order to reach the desired future Lean state.

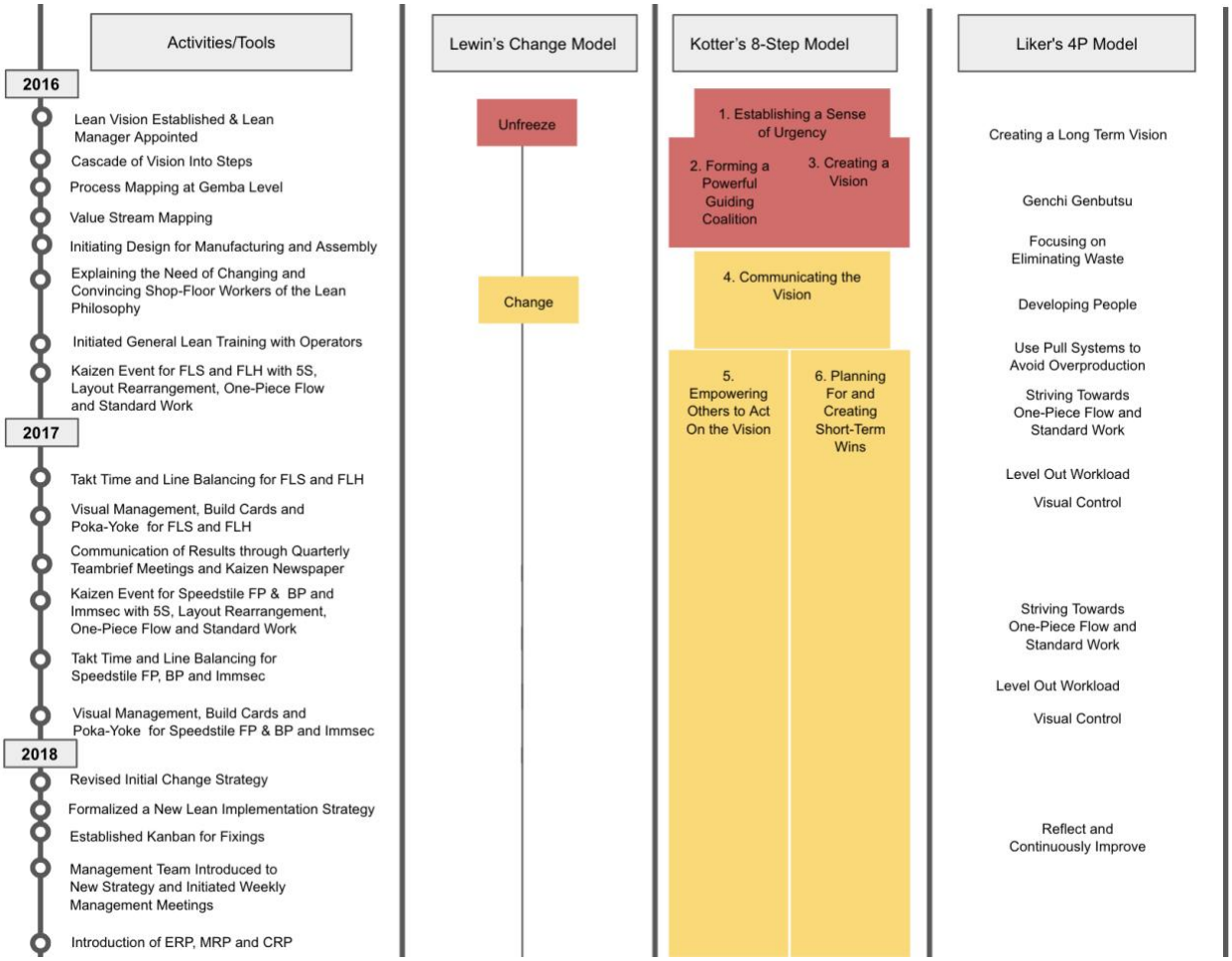

Figure 59, The Lean activities during the initial phase in correlation to change management

During the initial phase of the Lean transformation, Gunnebo reached the change state in Lewin's Change model and approached the first six steps of Kotter's 8-step model. The primary principles of Liker that was followed by Gunnebo during this time of event was mainly *Creating a Long-Term Vision, Genchi Genbutsu, Focusing on Eliminating Waste, Developing People, Use Pull System to Avoid Overproduction, Striving Towards One-Piece Flow and Standard Work, Level Out Workload, Visual Control,* and *Reflect and Continuously Improve*. This refers to ten of the fourteen established Lean principles by Liker (2004). Despite this, the Lean transformation was considered to be too slow, as the minor spot improvements did not have an impact on the whole production plant. Therefore, the change strategy got revised and the Golden Line project was formalized, which was more connected to their initial long-term vision.

The connection between the sequencing of activities, Kotter's 8-step model and the house of Lean as discussed by AlManei et al. (2018), can also be identified in this change. Gunnebo has

emphasized to create a steady foundation, which has been enabled through standardization. An increased Lean maturity within the organization further led to more extensive Lean activities, with takt time and Kanban, which can be located in the walls of the Lean house. The majority of the tools and activities that were utilized between 2016 and 2018 were advantageous during the early implementation stage as they were easy to communicate and provided short-term wins which empowered the employees in the change. Contrary to AlManei et al. and the Lean House, the implementation of a one-piece flow should normally be implemented at a later stage of the Lean transformation when the Lean maturity is higher. However, in this specific context, a one-piece flow had significant impacts on the space utilization, and the gained capacity provided the short-term wins that were necessary and important in convincing and motivating everyone to change.

5.1.2 Preparing for the Golden Line Implementation

The first quarter of 2019 followed a revised Lean transformation project, the Golden Line, which included all the preparatory work for the extensive transformation in the second quarter of 2019. The actions during this period are visualized in figure 60, and Gunnebo at this stage were still in the change phase, thereby involving the fourth, fifth and sixth step of Kotter's 8-step model. The work during this period was similar to the previous years and thereby no additional principles of Liker's 4P-model were approached. However, the spot improvements through Kaizen events with product categories B, D, and G were now serving a higher purpose which supported the long-term vision. Despite this, the short-term profits were not compromised, with Kaizen event B, resulting in three product lines being compressed to a 75% smaller area, while still managing to increase the capacity by 64.3%. This shows that actions supporting a long-term vision do not necessarily have to be at the expense of short-term gains.

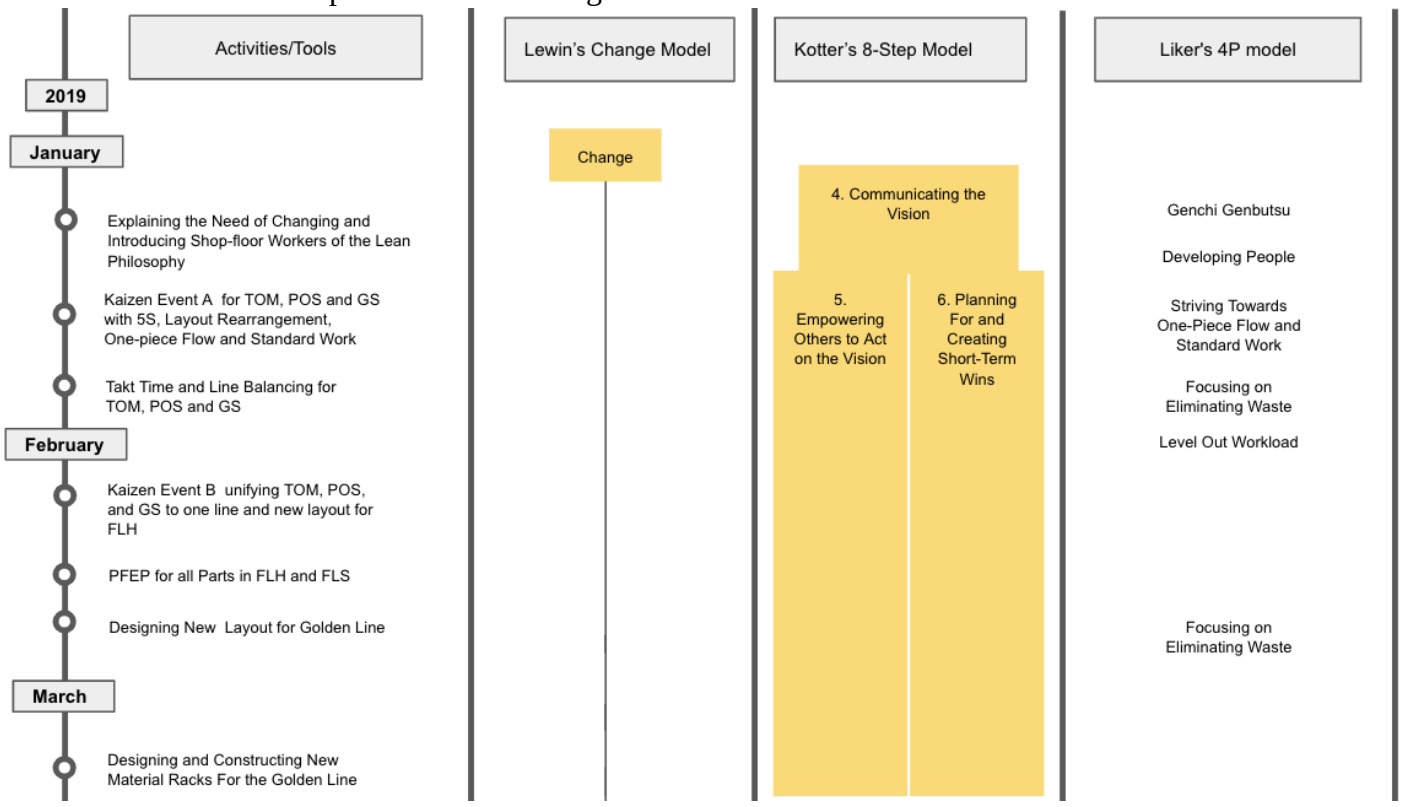

Figure 60, The Lean activities during the first quarter of 2019 in correlation to change management

5.1.3 Implementing the Golden Line

The implementation of the Golden Line was conducted and completed during the second half of March 2019. This implied an extensive transformation of two products in product category A (FLH and FLS) and an implementation of ERP, MRP and CRP system for affected products. The actions during this period are visualized in figure 61, and even if no new principles in Liker's 4P-model were approached, it did include two new high maturity Lean practices with the implementation of a Mizusumashi and Heijunka scheduling. As highlighted previously, these practices got implemented quickly without clear communication or complete training, which created confusion among the blue-collars. With the Golden Line project in place, more emphasis was on the refreeze-stage, and Kotter's 7th and 8th step. The refreeze phase was essential for Gunnebo as the expressed confusion and arising problems could be sorted out through minor corrections and spot improvements. A problem-solving methodology, A3 form, was also initiated for the production lines to continuously solve problems as they occur and prevent repeating issues. The success of this period was built upon the early gains and a higher Lean maturity within the company which enabled further deployment of Lean tools and practices, and a sustainment of the Lean culture. In addition, the new production layout was institutionalized once the new production lines were functioning. Furthermore, a value stream box score was introduced to replace the current KPIs in order to further encourage the new behaviors, both for blue- and white-collars.

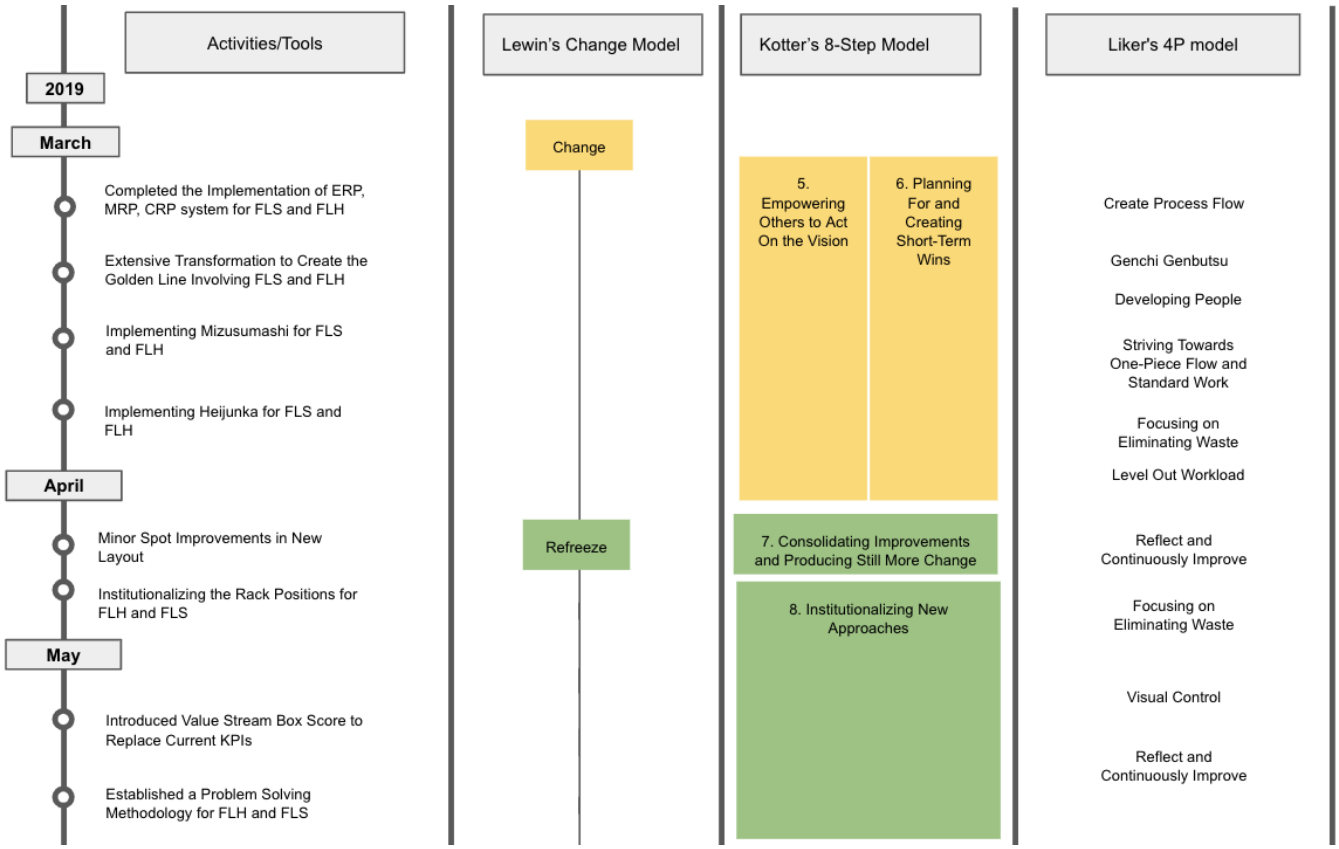

Figure 61, The Lean activities during the Golden Line implementation in correlation to change management

Notably, the previous years of the Lean transformation have increased the Lean maturity at the company, thus more extensive changes were possible. The successful implementation of the Golden Line project was a consequence of the preparatory work during the first quarter of 2019, which was enabled due to the revised planning in September 2018, which was based on the defined long-term goal in 2016.

5.1.4 Future State of the Lean Transformation

The future state for Gunnebo will initially continue to focus on the refreeze phase to ensure that the new behaviors will be institutionalized, in accordance to Kotter's 8th step (as demonstrated in figure 62). This is a vital state for the Lean implementation, as research demonstrates that even if benefits are gained initially from a Lean implementation, the majority still fail to sustain the continuous improvement efforts (Yadav et al., 2017). Gunnebo's approach to sustain the change will involve continuous development of people and leaders, which correlates with Liker's 9th and 10th principle. In addition, the company aims to improve the current working environment to show the employees that the change is mutually beneficial and that the future state will improve for everyone.

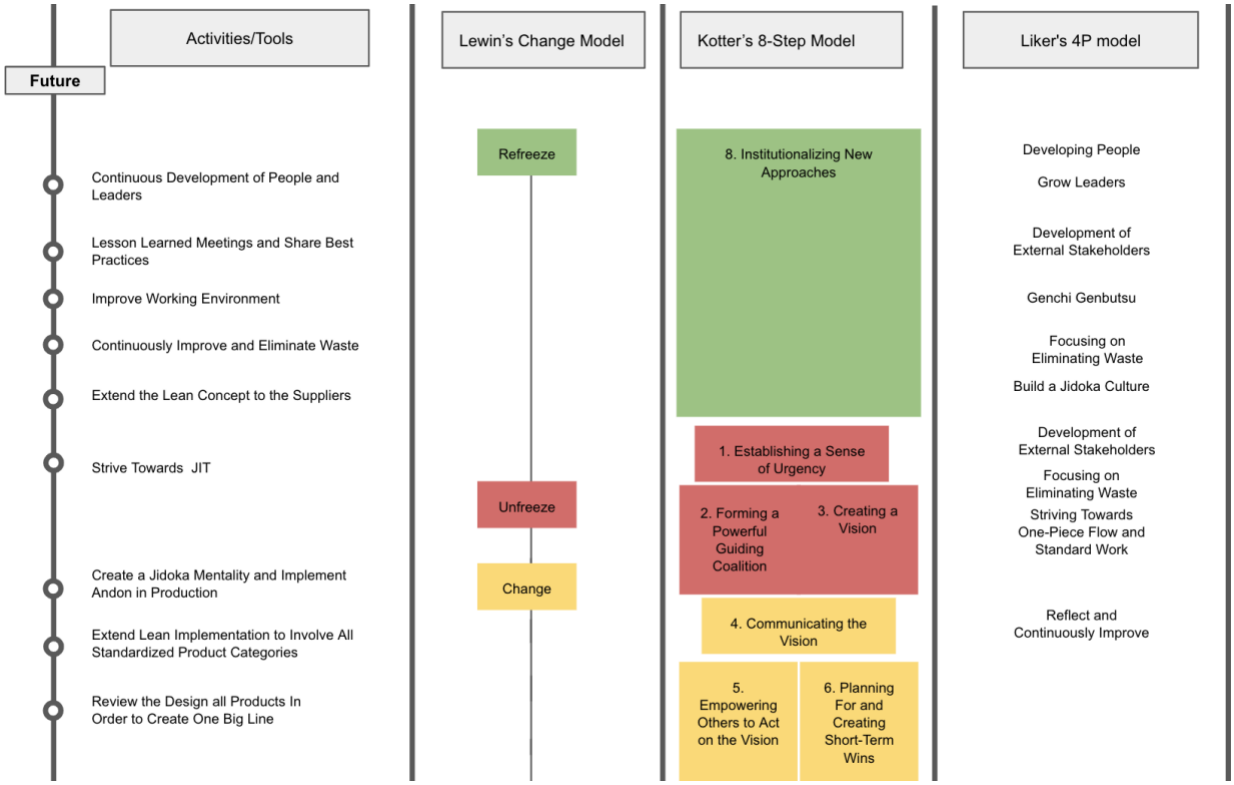

Figure 62, The intended Lean activities for the future state

The company is aware of that more changes and improvement efforts are needed; thus, a new change cycle will occur in the future. It is important that the time plan for the upcoming steps are decided in the near future to make sure that the continuous Lean improvements are sustained. In

the current state, with increased organizational Lean maturity through previous successful Lean implementations, further extensive changes can take place at all levels of the company. For instance, the company is mainly missing two out of Liker's 14 principles: *the Development of External Stakeholder and Building a Jidoka Culture*. These are already planned for, with Andon and extending the Lean concept to suppliers, being included in their long-term vision. We argue that the Golden Line initiative has significantly improved the production in accordance with Lean, and the production of FLH and FLS are considered to be more Lean now than in the past. However, the company is aware that there is still a long journey ahead of them and the company cannot be considered Lean until all standardized product categories are included. Accomplishing these changes will further increase the Leanness of Gunnebo, and they would be considered to be a Lean organization according to the 4P-model of Liker. Despite this, it should be stressed that the Lean transformation cannot stop there, and the fulfilment of each principle can always be improved to another level. Most important is the continuous development of people in the organization, which are responsible for embracing and developing the Lean culture.

5.1.5 Suggested Lean Transformation Framework

In summary, an effective approach to a Lean transformation could be the following holistic framework, shown in figure 63. The procedure is similar to the successful Lean transformation at Gunnebo but is presenting an effective framework based on well-established change management and Lean theories, i.e. Lewin's change model, Kotter's 8-step model, Liker's 4P-model and Lean sequencing model by AlManei et al. As previously mentioned, a heavy focus should be towards Genchi Genbutsu, as stressed by Liker (2004), to understand the situation and identify the need. Thereafter, a long-term vision can be established and the development of the people in the Lean philosophy can be initiated. When entering the change state, it is important that everything is planned into detail and that the employees are fully aware of the adopted procedures. This will enable a rapid implementation of the carefully chosen Lean practices as suggested by Liker. Furthermore, the achieved improvements should be communicated in order to increase the motivation and change mentality among the employees, as emphasized by Sisson and Elshennawy (2015) and several change management researchers (Beer & Nohria, 2000; Kotter, 2007; Nadler & Tushman, 1997). The early change phase could beneficially focus on the lower Lean maturity tools, and more extensive tools could be utilized at a later stage, as suggested by AlManei et al. (2018). Notably, as with the case of Gunnebo, higher maturity Lean tools (within the Jidoka and Just-in-Time pillars) can also have success early, which further stress the importance of Genchi Genbutsu and investigating the specific needs and possibilities. Lastly, after the change phase, it is important that further changes are produced and that the new approaches get institutionalized. When the organization has developed internally it should then be considered to extend to external stakeholders.

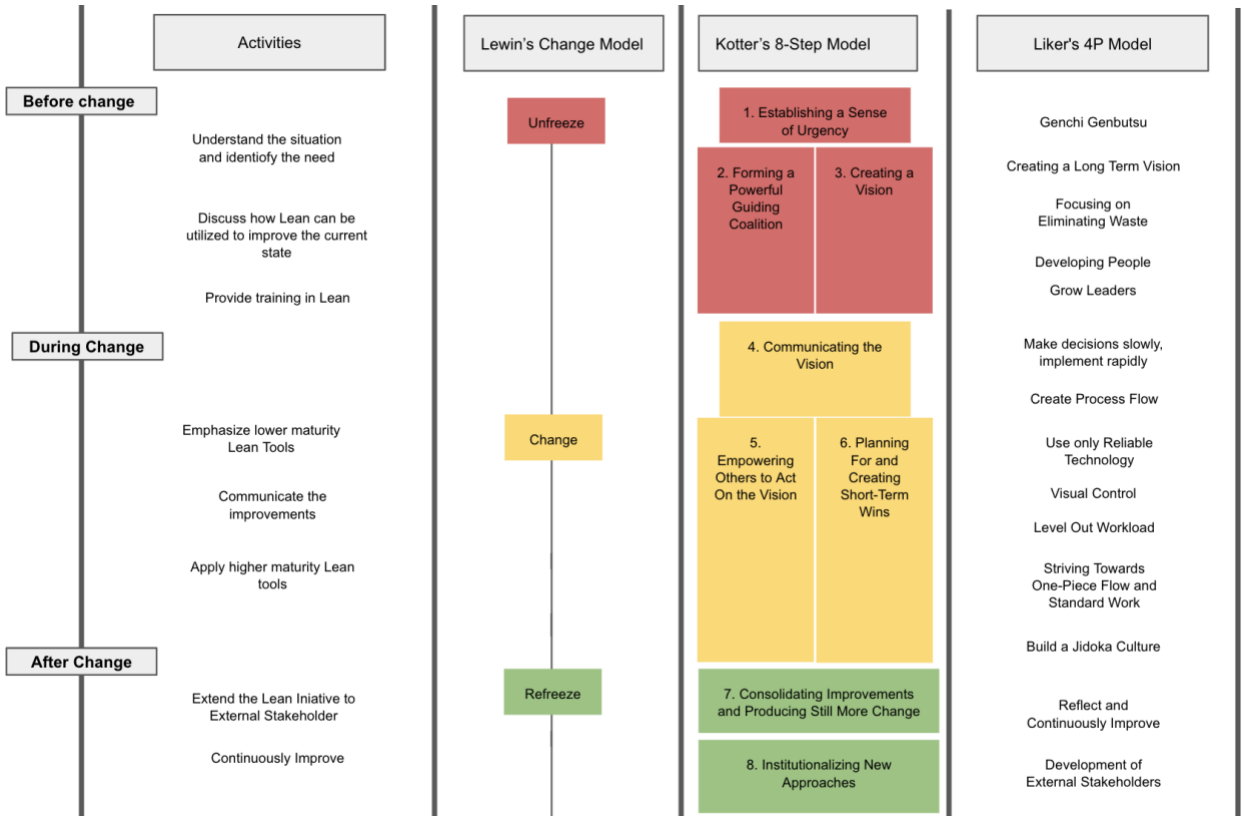

Figure 63, Demonstration of the suggested framework for Lean transformations

5.2 The success of the Lean Transformation by Gunnebo

The previous analysis of the Lean transformation demonstrates that it is a Lean transformation as well-established Lean principles have been approached. Therefore, the success factors by Sisson and Elshennawy (2015), and Shaw and Ward (2007) are applicable to the case study. This chapter intends to discuss and validate the success factors presented by Sisson and Elshennawy, supported by other discussed theories. The sequence of the analysis is structured by the six key constructs of Sisson and Elshennawy, where the 17 success factors (SF) are analyzed.

In summary, the achieved level of each success factor for Gunnebo can be described in figure 64. The SF 1, 2, 5, 10, 11, 15 and 17 have been succeeded at a high level and are not in direct need of revision. The SF 3, 6, 7, 8, 9, 12, 13, and 14 performed at a moderate level and will require continuous emphasis. The remaining, SF 4 and SF 16, are at a low level or not thoroughly considered, and will need more focus in the future in order for Gunnebo to fully comply with Sisson and Elshennawy's success factors. Notably, SF 4 and SF 16 require a high Lean maturity as they are located in the walls of the Lean house, and it is therefore understandable that they remain.

Low Level	Moderate Level	High Level
SF4: Extend to suppliers SF 16: Have their own version of the Toyota production system	SF3: Consider both manufacturing and non-manufacturing areas SF 6: Provide regular communications on Lean SF7: Adopt HR policies that support Lean goals SF8: Invest in training for employees SF9: Developing internal Lean leaders and senseis. SF12: Utilize Hoshin Kanri or policy deployment SF13: Use the VOC as a driver of improvements. SF 14: Utilize kaizen at a regular cadence	SF 1: Drive iniative through top-down SF 2: Utilize consultants to guide initial learning SF 5 : Dedicate full-time resources on Lean improvements SF 10: Utilize value stream mapping SF 11: Utilize standard work SF 15: Utilize appropriate metrics and visual management SF 17: Recognize that developing a Lean culture is a lengthy process

Figure 64, Demonstration of Gunnebo's compliance with the seventeen success factors

5.2.1 Deployment

SF 1: Successful Lean companies drive the implementation top-down

The Lean implementation at Gunnebo was initiated from top management who reckoned that a change was necessary. Thereafter, middle management was the main driver of the change with the support of both white-collars and blue-collars. The implementation therefore followed the suggestion by Nightingale and Srinivasan (2011), with the initiative starting from the top and later developing to a hybrid over time. The heavy emphasis at Gemba-level of the transformation and the daily presence of management involvement in the shop-floor turned the change into a bottom-up initiative and not something that the blue-collars were being forced upon.

SF 2: Successful Lean companies utilize consultants from established Lean companies like Toyota as senseis to help guide their initial learning and Lean improvement.

Gunnebo has not used consultants per se, however, it can be argued that it is not the consultant that is important but rather the knowledge. By looking at the success factor in this way, this issue was tackled by hiring a full-time Lean manager, accompanied by a project leader with a history of consulting within Lean manufacturing, which brought the necessary expertise to implement Lean. In addition, trips to known Lean factories were held in order to inspire the employees of which principles or solutions that they could adopt. Therefore, it can be argued that the premises of this success factor were managed, but in a different way than Sisson and Elshennawy suggests.

SF 3: Successful Lean companies implement Lean in both manufacturing and non-manufacturing areas

During the Lean transformation at Gunnebo two areas of focus have been discussed, the improvements in the material flow and the improvements of the informative flow. These improvements in manufacturing correspond to efforts in the material flow, and the non-manufacturing improvements correspond to the informative flow. Although Lean principles have been observed in both areas, a greater focus has been on the manufacturing improvements. As discussed by Sisson and Elshennawy the importance of acknowledging the non-manufacturing areas are essential for sustaining the Lean culture and should therefore be emphasized in the future.

SF 4: Successful Lean companies recognize that once they have made progress with becoming Lean internally, they must extend it to their suppliers

The fourth success factor is further supported by Shaw and Ward (2007) who argues that having strong relations to the suppliers is vital, as demonstrated in their three principles: *Supplier Feedback, JIT Delivery by Suppliers* and *Supplier Development*. This success factor has only briefly been managed by Gunnebo as initial plans on how to extend Lean to their suppliers has been drafted but not carried out. This can be argued to be understandable as Gunnebo is still developing the Lean culture internally and are thus not ready to extend it. Despite this, there are as mentioned plans and the importance and value of extending Lean to suppliers are recognized by Gunnebo. However, this is a key area to focus on in the future to sustain a Just-in-Time and pull production flow and further expand the Lean knowledge internally.

5.2.2 Engagement

SF 5: Successful Lean companies dedicate full-time resources on Lean improvements

Sisson and Elshennawy suggest that 3% of the available resources should be devoted to Lean improvements. Two managers (Lean manager and Project leader) at Gunnebo worked full-time dedicated to the Lean transformation and an additional eight other managers dedicated 20% of their time to Lean efforts. Additionally, manpower from production was used during layout rearrangements and other preparatory activities, 5S or Kaizen events. Only counting the Lean

manager and the project leader accounts for 2.8% of the available resources. Therefore, with the assistance of the remaining white- and blue-collars, Gunnebo reached and surpassed the recommended allocation from Sisson and Elshennawy. Additionally, Sisson and Elshennawy state that additional capacity gained from Lean improvements should be allocated to new Lean improvements which were also observed at Gunnebo. For instance, once capacity had been gained in the production line, blue-collars were instructed to find additional ways to improve the production lines with the newfound spare time.

SF 6: Successful Lean companies seek to provide regular communications on Lean throughout the organization

When reflected upon the success of the implementation, this area was generally agreed as one that could have been improved. The management team involved in the Lean transformation had weekly meetings which were sufficient for periods without much change, but insufficient during phases of more extensive changes. Furthermore, interviews revealed that the operators did not receive enough communication. Most communication to the operators was done during casual conversations which led to only a few having an understanding of what was happening in other departments or stations. It is important to stress the impact of insufficient communication, and as Koenigsaecker (2016) suggests, it is not possible to "over-communicate" which should really be kept in mind during a big transition which seeks to change the status quo for all employees. Although this issue was managed at a level so that no decisive failure occurred, this is an area that must be reviewed as the transformation continues.

SF 7: Successful Lean companies adopt HR policies that support Lean goals

Sisson and Elshennawy suggest that a good way to engage people in Lean is to use incentives such as pay or bonuses based on Lean targets. At Gunnebo, these incentives were not possible due to local regulations and policies formed by the unions. However, interviews revealed that the new Lean hierarchy and the new roles acted as a motive for employees to engage and take interest in the Lean philosophy. One could also argue that HR played an important role in hiring the Lean manager and the Project leader to ensure that the right set of skills to perform a Lean transformation existed internally. Further, Alagaraja (2013) claims that it is important that the HR department is involved in developing Lean training programs, which will be key for sustaining and continuing the progress of the Lean transformation in the future.

5.2.3 Training

SF 8: Successful Lean companies invest in training for employees to learn about Lean.

Gunnebo have performed adequately in this area as training sessions have been conducted repeatedly. A general introduction to Lean was given early by an external organization and additional training for those who would have a new Lean role, i.e. Mizusumashi, or for those who would use new tools like the ERP-system. In addition, brief training sessions were included in every Kaizen event for those involved with several sessions planned in the future. Further, it exists

an internal Lean bibliography with articles and books that could be accessed by anyone. However, no one is encouraged to utilize this bibliography, and the massive amount of literature makes it complex for a beginner to comprehend.

It was revealed during interviews that employees wanted to have more training sessions to be able to expand their expertise in the area, which was not provided in a sufficient matter. In addition, the training was not provided for everyone which led to some confusion regarding what was happening in the production lines. This is an area that should be highlighted in the upcoming stages as both Bhasin (2012) and Yadav et al (2010) claims that insufficient understanding of Lean is one of the main reasons for failure. According to Liker and Convis (2012) a time-consuming and expensive investment in training is the recipe for success. Therefore, an increase in training could be crucial in the future to successfully sustain the Lean culture.

SF 9: Successful Lean companies see value in developing internal Lean leaders and senseis.
There are currently no plans to develop Lean leaders in the company, other than the Lean manager and the Project leader. Despite this, some operators have become unofficially Lean ambassadors in the production lines. For example, the Mizusumashi has gotten additional training which has led to him being the Lean leader in the production line, which could assist when there was confusion among blue-collars regarding Lean objectives. Therefore, even if there were no plans to develop specific Lean leaders, some have taken these roles naturally. It will be vital to develop these people further to ensure that they possess an accurate image of Lean so that false information or misunderstandings can be stopped from spreading. Further, they will play an important role if the current Lean leaders leave the organization to sustain the Lean culture.

5.2.4 Processes

SF 10: Successful Lean companies utilize value stream mapping to identify and drive improvement opportunities
This was acknowledged by Gunnebo and was one of the first steps after the Lean transformation was initiated. According to Koenigsaecker (2016) it is key that senior management creates a corporate-wide value stream map to allow for effective resource allocation in areas of opportunities. By creating a value-stream map it was possible to set a current state and in combination with a waste analysis, identify the main improvement areas, i.e. capacity improvements and lead time reduction.

SF 11: Successful Lean companies utilize standard work as a baseline for continuous improvement
Standardized working procedures has been observed both in production and in non-manufacturing areas. In-depth build instructions for all products in The Golden Line were developed which are regularly reviewed to support the standard work. Despite this, some deviations to the build instructions have been observed in the sequencing of operations, varying from operator to operator.

In terms of best practice, the sequencing of operations may not be decisive. However, in order to make the line balancing more accurate, these deuteriations from the decided standard work must be avoided through more training and communication. Nonetheless, this is an area that has been respected throughout the transformation and the processes are relatively robust but can be further developed in future activities.

SF 12: Successful Lean companies utilize Hoshin Kanri or policy deployment to align company goals and Lean strategies.

By dividing the enterprise-wide strategy into simple objectives and goals for each level in the organization, improvement projects can be clearly linked to the Lean philosophy and the organizational strategy. This was recognized at Gunnebo which however was managed at an insufficient level. Interviews revealed that some departments were uncertain of what was expected from them in the Lean transformation and how the Lean activities were connected to the organizational strategy. This can be connected to the inadequate performance in SF 6, i.e. communication, where an insufficient level of communication and regular, perhaps daily, discussions with key personnel could drastically improve this. Consequently, this will be an area that must be investigated further once directions are further established to ensure that all improvement projects are aligned to the organizational strategy and the Lean philosophy.

5.2.5 Drivers

SF 13: Successful Lean companies use the Voice of the Customer (VOC) as a driver of improvements.

Sisson and Elshennawy (2015) stress that it is crucial that the VOC is at the core of every product and process and it is therefore central to create a culture which puts the customer focus first. This is further supported by Shah and Ward (2007) who claims that customer involvement is a key aspect of Lean where the customer needs require significant emphasis. It can be argued that the VOC was the foundation of the Lean transformation as expected outcomes of the transformation was reduced Lead times and improved efficiency, which in turn, can reduce product prices. In addition, non-conformities submitted by customers are actively recorded and gathered from which improvement projects are initiated. However, there are currently no plans to collect the VOC other than for non-conformities. This could be a missed opportunity to get valuable feedback or ideas on how to improve products or services and may be an area which can be investigated further.

SF 14: Successful Lean companies utilize Kaizen at a regular cadence to drive continuous improvements

Eight Kaizen events have taken place at Gunnebo over the course of three years, and whether this is considered “regular” or not is open for interpretation. What has been observed is that the Kaizen events at Gunnebo are quite different than what Imai (2012) describes as Kaizen events. Rather than small and incremental improvement events, the Kaizen events at Gunnebo has been at a larger scale, often involving multiple white-collars and blue-collars and conducted over a full week.

Sisson and Elshennawy stress that senior management should participate as it can encourage a devotion of further resources based on their identified wastes during the event. However, there has not been a significant senior management participation at Kaizen events and most responsibility has been delegated to middle-management. Furthermore, as Koenigsaecker (2016) states that Kaizen events are key in developing a self-sustaining Lean organization, the Kaizen events at Gunnebo could beneficially be reduced to smaller scale as lower investments enable improved frequency and thereby maintain continuous improvements.

SF 15: Successful Lean companies utilize appropriate metrics and visual management to drive Lean improvements

It was acknowledged early in the transformation that visual tools, like the visual boards presented in 4.3, to present performance in the production lines was an effective way to identify improvement opportunities and to demonstrate the advancements. The mindset of keeping everything visual was also observed with the floor markings with designated areas for racks and workstations with plans to fully implement a 5S system of visual instructions where to store items. In addition, the value-stream box score was implemented early May 2019 with new metrics to shift the organizational focus to Lean metrics and motivate for Lean behavior. Not only did it put emphasis on a value-stream perspective, but also changed metrics that previously promoted a large lot-size production to instead promote one-piece flow.

5.2.6 Culture

SF: 16 Successful Lean companies have their own version of the Toyota production system that is not just a document but a significant part of the company's culture

Gunnebo Group's version of the TPS, Gunnebo Operations System (GOS) was a document created six years ago which was emphasized at an early stage. However, since the Lean initiative started in 2016, GOS has been left untouched and forgotten. For the sustainment of the change, it will be vital that a reviewed and carefully deliberated GOS is developed so that it can be used in future decision makings to ensure that all efforts share a higher purpose and strategy. In addition, Gunnebo could beneficially share their experiences, where a reopened GOS initiative could be utilized by other manufacturing plants within Entrance Control.

SF 17: Successful Lean companies recognize that developing a Lean culture is a lengthy process and that Lean is never-ending.

In accordance, Koenigsaecker (2005) claims that developing a Lean culture generally takes at least a decade. It is agreed throughout Gunnebo that the development of a Lean organization will take many years and that having a long-term focus is central. However, until this point, no massive setbacks have occurred which makes it difficult to say whether or not people will continue to do the "Lean" way even in times of crisis.

5.3 Main Challenges Identified during the Lean Transformation at Gunnebo

The challenges at Gunnebo during a Lean transformation are similar to any extensive organizational change. As discussed in the theory, a change often involves opposition due to employees experiencing uncertainty, ambiguity, and anxiety, which creates certain challenges. As studies have shown, extensive change processes have a fail rate of 70% which is not different from the context of a Lean transformation (Beer & Nohria, 2000). In correlation with the sequencing of activities, it can be argued that any organizational transformation has the same needs, and the approach could beneficially be following Lewin's change model and Kotter's 8-Step model. In addition, as with any implementation of a practice or philosophy, it is required that the organization possess the theoretical knowledge and has clear ideas on how it can be utilized in their specific context. Gunnebo had acknowledged that a failure in Lean transformation often derives from viewing Lean as a toolbox to address certain internal problems. Consequently, this increased the chances of a successful Lean implementation, as the Lean leaders within the organization have thoroughly investigated the situation and instead followed the Lean principles. Discussed below are the eight main challenges that were identified at Gunnebo, and as can be seen, there are major similarities with other organizational transformations. It should be noted that all the internal challenges, challenge 1-7, have been addressed to an acceptable level, which is a reason for the success of the Lean transformation. Furthermore, the eighth challenge, i.e. extending Lean to suppliers, will be further discussed when they are fully developed internally.

1. Overcoming Resistance and Changing the Mentality

Employee resistance is according to Beer and Nohria (2000) a significant challenge and a major factor of failed change implementations. Similar to the theory, the organizational change at Gunnebo resulted in resistance as a consequence of employees experiencing uncertainty, ambiguity, and anxiety. In addition, changing the mentality was complex with employees that have been working in the same patterns for over 15 years. In addition, the current positive company growth hampered the change mentality as results did not force them to immediately change. However, the production contained major wastes and the market grew faster than the company, which essentially implied that the company was losing market shares due to previous capacity and lead times. Gunnebo had a significant emphasis on overcoming this resistance and gaining a critical mass of support, as stressed by Nadler & Tushman (1997).

Initially, potential change drivers for each department were formed by inspiring and motivating the management team through visits to high performing Lean plants. Once the Lean initiative got introduced to the blue-collars, the management team was clear that the change would not result in any layoffs or increased workload, and that it would only improve the current working environment. Convincing the employees in the change was further enabled through heavy

management presence in Gemba which enabled identification of potential early gains. The early gains could be demonstrated and backed with figures, and the implementation of a one-piece flow was claimed to be the major activity that convinced everyone in the philosophy.

Notably, convincing and changing the behaviors of the white-collars was in the end claimed to have been a more difficult task than with the blue-collars. As stated earlier, the white-collars were not fully aware of what was needed of them. This stress the importance of also focusing the communication towards the white-collars, and similar to the blue-collars, thoroughly explain the reason and the benefits of their changed behaviors.

2. Communicating the Change

As mentioned in 5.2.2, communication was one of the areas that were proven to be a challenge. Despite having weekly Lean meetings, with the managers involved in the transformation and quarterly based "Town hall" meetings available for everyone, it was stated by both blue- and white-collars that there was uncertainty regarding what was happening in other departments. Instances where misunderstandings due to lack of communication between white-collars, which led to detrimental behaviors were observed. Additionally, insufficient communication was noticed in the shop-floor where confusion arose regarding certain Lean tools and what was expected from them. It can be argued that one of the causes of the insufficient communication was due to the fast tempo of the implementation, and therefore the predetermined frequency of meetings was not enough. The importance of continuous communication throughout the change and organization has been acknowledged by both Kotter (2007) and Koenigsaecker (2016). Moreover, Brown (2012) suggests that gathering feedback from employees should occur many more times than anticipated which is an advice that Gunnebo could beneficially follow to improve.

Nonetheless, the change drivers had sufficient information to know whether the departments could achieve their goals or not through the weekly Lean meetings. In addition, it should be noted that the communication of the purpose can be argued to be successful as the company never faced any significant resistance from operators or their unions. However, it has been an observed challenge at Gunnebo and an area that could be further improved in the future.

3. Sustaining the New Status Quo

Although initial success is gained for a Lean implementation, Yadav et al. (2017) claim that the majority still fail to sustain the achieved state. For Gunnebo the Kaizen events resulted in initially changed behaviors or freed up space, which were challenging to sustain. The challenge mainly derives from the insufficient success of the other challenges. For instance, due to lacking communication between the white-collars turned an intended freed up improvement area to be a storage area. Furthermore, every blue-collar were not fully convinced in the one-piece flow and

they were missing communication and Lean training. Additionally, with changes being planned and executed too fast, resulted in lacking understanding of implemented practices or lacking consideration of all aspects of the production. This resulted in deviations from the intended behaviors which was not necessarily due to resistance. However, by discussing these problems the blue- and white-collars could find an agreement or a solution that instead could be sustained.

4. Planning for Change

Beer and Nohria's (2000) second factor of failed change implementations is ineffective planning. Due to the scale of the transformation at Gunnebo, everything had to be planned in advance to ensure that the right resources were available. Despite this, due to optimistic deadlines and time pressure from stopped production during layout rearrangements and Kaizen events, forced the transformation at a faster pace than optimal. This resulted in a heavy workload for the Lean manager and the project manager, and all preparatory operations could not be fully executed before the events. Therefore, a conducted Kaizen event could still remain important operations which could affect the outcome of the change. Consequently, the state after change required more emphasis to cover up for the rushed transformation. Therefore, planning for the transformation was proven to be a challenge, as a high level of flexibility was needed in order to adjust for delays or other obstructions.

5. Balancing Lean with Ordinary Work Tasks

An extensive organizational change will result in new work tasks for everyone. Sisson and Elshennawy (2015) stress the importance of dedicating full-time resources to Lean activities to create an environment that motivates for engagement. In accordance, Koenigsaecker (2016) recommends that roughly 3% of an organization's resources should be focused on Lean. The balancing of their ordinary operations was difficult for the white-collars, as the Lean tasks did not have the highest priority. Consequently, the Lean tasks tended to be postponed which slowed down the Lean transformation in the non-manufacturing areas of the company.

6. Defining and Implementing Relevant Lean Tools

Although not strictly mentioned in the interviews and perhaps not reflected upon by the management it has arguably been a challenge to understand, define, adapt and implement a Lean practice. For instance, the implementation of a Heijunka or Mizusumashi requires heavy amounts of planning, which has to be adapted to comply in their own context as stressed by Liker (2004). To support for an implementation of a Mizusumashi in the end of March 2019, it required two months to establish a PFEP, form a suitable production sequence and build racks accordingly. Thereafter, training for this practice was needed for two blue-collars in order to make sure that the knowledge always existed within the production.

7. Implementing New Lean Roles

The Golden Line resulted in an introduction of new roles related to the Lean philosophy, for instance, operators for sub-assemblies, main assembly, testing & packaging, a Mizusumashi, a value stream planner. This was proven to be a challenge as issues arose when people were absent and replacements were necessary, as only a few people had training and competence to fulfill the roles. When implemented, it was further a challenge to make everyone understand the practice and how it should be utilized. A few weeks after the Golden Line implementation everything was running smoothly which proves that, even though a great challenge, it has been managed successfully. However, this challenge can be further emphasized, as Liker (2004) suggests that continuous training and developing multi-functional individuals will improve the quality, productivity, and production flow.

8. Extending Lean to Suppliers

Several researchers stress the importance of supplier involvement in Lean activities (Koenigsaecker, 2016; Liker, 2004; Shah & Ward, 2007; Sisson & Elshennawy, 2015). Extending the Lean initiative to suppliers is a major challenge for Gunnebo, which has not yet been accomplished. Arguably, this can be connected to the fact that the company is not fully Lean internally and thereby has this activity on hold. However, the interviews revealed that it would be challenging and might not possible to succeed with. The main reason for this is argued to be the size of the company, which implies a low bargaining power among the suppliers with none being dependent on their orders. Despite this, Gunnebo still aims to approach this area, and a Lean section will be implemented in their supplier audits. Moreover, a Lean supplier will be prioritized over a regular supplier when the options are available.

6. Discussion

This chapter aims to present a personal reflection on the findings and discuss the quality of the study. The first section aims to compare the findings with the results from the theory in order to detect similarities or discrepancies with the study. The second section will examine the quality of the research by evaluating the credibility, dependability, confirmability, and transferability.

6.1 Reflection on Results

The following subsections discuss the findings of the study, which follows a similar structure as the analysis. The aim is to detect similarities or discrepancies and discuss the underlying reasoning of the achieved results.

6.1.1 Change Management during Lean Transformation

The Lean implementation at Gunnebo covered the Lean principles suggested by Liker (2004), and the successful transformation can be derived from its compliance with two well-established change management theories in terms of Lewin's change model and Kotter's 8-step model. Additionally, the sequencing of tools and activities partially followed the house of Lean and the sequencing model by AlManei et al. (2018). The major difference between theory and practice was the early implementation of a one-piece flow that is considered as a high Lean maturity activity, located in the walls of the Lean house. However, the proven success of the one-piece flow implementation demonstrates that even higher maturity tools could be beneficial at an early stage. For the case at Gunnebo, we claim that the early implementation of the one-piece flow was vital in the successfulness of the Lean transformation, and the achieved critical short-term wins were important in convincing and motivating everyone to change. Therefore, we argue that it is not possible to fully define a road map with step by step tools to implement. As Liker (2004) claimed, a Lean transformation has to be adapted to the company and the context. This was further stressed by Nightingale & Srinivasan (2011) which also added that the applied tools have to consider the strategic objectives of the company.

Our proposed best practice is a holistic framework following Lewin's change model and Kotter's 8-step model while striving towards the principles by Liker. We argue that it will force companies to recognize change management while simultaneously adapting Lean tools to their specific context and need. Thus, we suggest that it is an effective framework to consider for all Lean transformations. Utilizing tools that require a lower Lean maturity could facilitate the initial change process and generate the short-term wins that later enable the higher maturity practices. In the case of Gunnebo, strictly following this framework would initially suggest that the one-piece flow should be considered at a later stage when the Lean maturity within the organization was higher. This could have affected the initial short-term wins, thereby risking the positive change mentality towards the Lean transformation and potentially increasing the probability of failure.

However, as our proposed holistic framework emphasizes Genchi Genbutsu and adapting the road to the specific context and need, would still lead to the conclusion of implementing the one-piece flow at an early stage. This is motivated by the fact that the Lean initiative at Gunnebo started from Genchi Genbutsu where there were clear signs of what immediate impact the one-piece flow would have.

Furthermore, Liker's first principle suggests that management decisions should be based on the long-term philosophy, even at the expense of short-term gains. Contrary to Kotter's 8-step model, the short-term wins are considered as vital and must be planned for. Arguably, Liker's 4P-model could be seen as philosophies for an established Lean company, and not a company in a Lean transformation, as the research derives from his time at Toyota. Moreover, this would imply that Lewin's change model and Kotter's 8-step model are more suitable for achieving success in the early implementation phases. In addition, the changes for Gunnebo that supported the long-term philosophy were proven to not compromise the short-term profits. Therefore, we argue that the actions supporting a long-term vision do not necessarily have to be at the expense of short-term gains. Additionally, thorough planning and consideration of tools and activities for a specific context increase the likeliness of achieving short-term profits even when the long-term vision is supported.

6.1.2. Lean Implementation Success

To objectively determine the success of the Lean implementation, one must first define what a Lean organization is. The complexity of this matter is well discussed in theory and as Lean is continuously evolving it has caused confusion and disagreements in its definition (Hines et al., 2004). Additionally, even if there have been attempts to develop quantitative measures to evaluate a level of "Leanness", it often results in fuzzy ratings that will be affected by subjectivity. However, we argue that the success factors by Sisson and Elshennawy (2015) and Shah and Ward (2007), in correlation to the principles of Liker (2004), provides a qualitative understanding of a Lean organization. It is therefore argued to be possible to determine the success of the Lean implementation by evaluating the maturity of each individual success factor, as demonstrated in figure 64. In addition, by looking at the targets set prior to the implementation and the results in table 4, clear improvements in performance can be demonstrated.

By spending 500 hours for observing and having informal conversations with both white- and blue-collars during the Lean transformation, we claim that the new production line and related processes comply with a high Lean standard of tools and practices. Consequently, we do consider it to be a successful Lean transformation. Nonetheless, there is significant work left to fully transform the rest of the organization and sustaining the new way of working with continuous improvement. Thereof, it is not possible yet to entirely define Gunnebo as a Lean company, and it is recognized that the implementation will continue for several years.

Lastly, we suggest that the success factors by Sisson and Elshennawy only present issues that must be managed and not the sequence of how they should be managed. Therefore, to maximize the chances of a successful implementation, a combination of the success factors and our suggested framework can be used to complement each other. Moreover, with our suggested holistic framework of a Lean implementation following change and Lean management theory, and approaching the success factors enables that all issues are managed throughout the transformation.

6.1.3 Lean Transformation Challenges

We argue that Gunnebo has accomplished a successful Lean implementation, thereby being a minority given that studies suggest a failure rate of 80% (Pearce et al., 2018) for Lean implementation programs. The main reason for succeeding in this Lean transformation can be argued to derive from Gunnebo initially acknowledging that the main cause of failure is due to viewing Lean as a toolbox to address certain internal problems. This resulted in Gunnebo being very critical when applying tools, and it was crucial that the chosen practices had clear benefits in their context and that it supported the Lean principles and the long-term vision. Moreover, overcoming the internal main challenges described in 5.3 further enabled a successful transformation.

Furthermore, the challenges at Gunnebo can all be linked with the success factors by Sisson and Elshennawy (2015) as seen in figure 65. Notably, none of the success factors with a high level of fulfilment resulted in any major challenges. Arguably, by thoroughly improving the fulfilment of the success factors categorized under low and moderate level, it should prevent the acknowledged challenges from reoccurring at Gunnebo. Additionally, it can be argued that challenge 1, 2, 3, 4, 5, 6 and 7 can be rooted from change management, with the majority connected to communication issues. With seven out of eight challenges connected to change management, we suggest that the need of a change management expert can be just as important as having a Lean expert in Lean transformations that involves people.

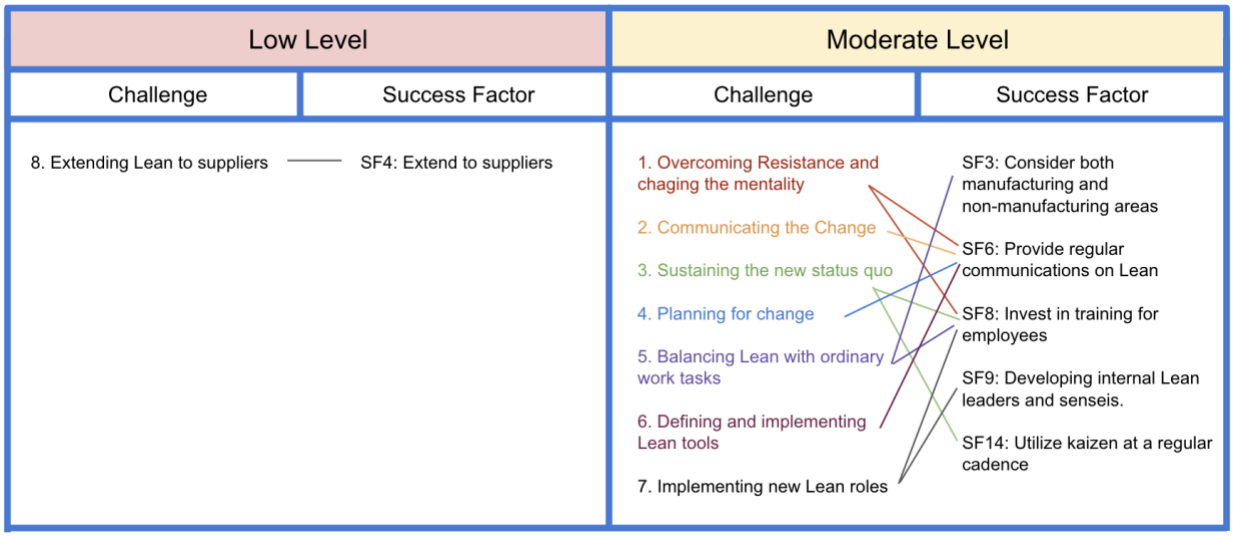

Figure 65, Gunnebo's challenges linked with the success factors by Sisson and Elshennawy

6.2 Quality of Research

Described below is a critical evaluation of the research quality to discuss the quality of the findings within the following four concepts: Credibility, Dependability, Confirmability, and Transferability.

6.2.1 Credibility

For the theoretical framework multiple well-referred research on similar topics has been used to complement each other and to find discrepancies in the literature. To achieve a high degree of credibility in the data collection of empirical data, multiple data collection methods, i.e. triangulation, has been used to study the same object. For empirical data regarding the initial state of the implementation, historical data archives have been studied in combination with semi-structured interviews. For the remaining empirical data, gathered between January 2019 - June 2019, triangulations have been applied by conducting observations, informal and semi-structured interviews, and quantitative data analysis. Therefore, we argue that the study has achieved and maintained a high degree of credibility throughout the research.

6.2.2 Dependability

Rigorous documentation has taken place with photographs and observational notes throughout the study. As previously discussed, the context and the environment matter significantly in a Lean implementation which we have aspired to describe as thoroughly as possible. Therefore, we argue that the dependability has been carefully considered through a detailed description of the methodology, consistent documentation, and provision of assisting material.

6.2.3 Confirmability

To mitigate the level of bias and achieve objectivity, multiple actors have reviewed and discussed the qualitative data to minimize misinterpretations. This was further validated with employees at Gunnebo where we could discuss our perceptions during informal and formal interviews. In addition, we were involved and had daily observations of the change which enabled us to build our own impression, and not entirely base it on the perspective of employees. Hence, we argue that the confirmability of the study has been kept at an unbiased level. Additionally, by supporting qualitative interpretations with well-established literature has maintained the objectivity of the findings.

6.2.4 Transferability

The limitation of only including one organization in the study can affect the transferability. However, we argue that by thoroughly comparing our own observations and findings with well-established theories increased the generalizability of our study. Additionally, the findings have been supported by well-referred literature, which implies that similar tendencies will be shown for other cases. Emphasizing a more holistic approach when implementing Lean will increase the transferability, with the suggested best practice being kept at an abstract level. However, the level of abstraction also implies that others must see to their own context and environment. Therefore, limiting the transferability in this matter, as the specific Lean tools used at Gunnebo is not necessarily applicable to other cases.

7. Conclusion & Managerial Implications

The extensive literature review of 65 publications resulted in an identification of 17 success factors in Lean transformations, which are critical to manage for organizations trying to implement Lean. The success factors consider several aspects of an organization, which can be categorized under six key constructs: *Deployment, Engagement, Training, Processes, Drivers, Culture.* Additionally, it was acknowledged that viewing Lean as a toolbox to address certain internal problems was the main cause of failure in Lean transformations. The case company was aware of this and was as a consequence very critical when applying tools. Hence, it was crucial that the practices would provide clear benefits for their context and that it supported the Lean principles and their long-term vision.

The continuously evolving Lean concept has resulted in confusion and disagreement regarding its definition among practitioners and academicians, which increases the complexity in determining the successfulness of the Lean implementation at Gunnebo. The Lean transformation at Gunnebo is claimed to have been successful which is based on a combination of quantitative measurements and qualitative judgments. The quantitative measurements prove that the affected product lines in the Lean transformation project have significantly improved the current state, through increased capacity and improved space utilization, with a working environment that supports the Lean philosophy. Further, the qualitative judgment of its successfulness is supported by observations and interviews during and after the Lean implementation project, which evaluation is accompanied by well-established Lean literature. Despite being a successful Lean implementation, it should be acknowledged that Gunnebo still has a long journey ahead, with remaining products, departments and external suppliers yet to be included.

Moreover, the findings suggest that Liker's 4P-model demonstrate a world-class Lean company and not a company in its transformation. Even though it is suitable to strive towards the 14 principles of Liker, it is evident that Lewin's change model and Kotter's 8-step model are more appropriate to follow during the early Lean transformation stages. Consequently, a holistic framework has been constructed based on the findings from literature in change and Lean management, in combination with the findings from the case study. The suggested approach to a Lean implementation is not a framework of tools to sequentially implement, but rather a suggestion on how the change can be managed during a Lean transformation. To maximize the chances of a successful implementation, a combination of the success factors and the suggested framework can be used to complement each other. Furthermore, the framework does not suggest the same sequence of specific Lean practices for every company, as this thesis and several other studies have proven, a Lean transformation like any other extensive organizational change must be adapted to the specific context and need in order to be successful.

The biggest challenges for Gunnebo were strongly linked with the lesser achieved success factors. In addition, the challenges faced at Gunnebo were also closely connected to change management aspects, which highlights the importance of not only acquiring the appropriate Lean expertise but also to consider having someone with expertise in managing an organizational change. The findings from this study identify change management as a vital aspect in extensive transformations, where a change management expert might be just as important as having a Lean expert.

Lastly, the following list of **managerial implications** should be considered when conducting a Lean transformation:

- ❏ Identify possible benefits in customer value before considering a Lean implementation.
- ❏ Thoroughly understand the principles of Lean before approaching the transformation.
- ❏ Investigate and analyze your own context and adapt the Lean tools and activities to your organizational environment.
- ❏ Do not neglect the importance of change management in a Lean transformation and the value of short-term gains.

8. Future Research

A future study at Gunnebo would be interesting to follow-up on the implementation to verify if the success of the implementation was sustained and continuous improvement has been maintained. Additionally, further data collection on performance can be important to prove that the improved KPIs due to Lean efforts is statistically significant. Additionally, further studies could be conducted to confirm the correlation between the success factors and the challenges faced during a Lean transformation.

To further test and validate the suggested holistic framework, additional case studies are necessary to statistically measure if it increases the probability of a successful Lean implementation. Furthermore, national culture may affect the specific sequencing and success of the implementation as the transformation put heavy emphasis on changing employee behaviors. Therefore, the framework could beneficially be put to test in different contexts of industries and cultural environments to identify discrepancies.

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Appendices

Appendix I - The Six Key Constructs of Successful Lean Improvement by Sisson and Elshennawy (2015)

Deployment

1. Successful lean companies drive lean implementation from the top down.
2. Successful lean companies utilize consultants from established lean companies like Toyota as senseis to help guide their initial learning and lean improvement.
3. Successful lean companies implement lean in both manufacturing and non-manufacturing areas.
4. Successful lean companies recognize that once they have made progress on becoming lean internally, they should extend lean implementation to their suppliers.

Engagement

5. Successful lean companies dedicate full-time resources to lean improvement.
6. Successful lean companies seek to provide regular communications on lean throughout the organization.
7. Successful lean companies adopt HR policies that support lean goals

Training

8. Successful lean companies invest in training for employees to learn about lean.
9. Successful lean companies see the value in developing internal lean leaders and senseis.

Processes

10. Successful lean companies utilize value stream mapping to identify and drive improvement opportunities
11. Successful lean companies utilize standard work as the baseline for continuous improvement.
12. Successful lean companies utilize hoshin kanri or policy deployment to align company goals and lean strategies.

Drivers

13. Successful lean companies use the Voice of the Customer (VOC) as a driver of improvements.
14. Successful lean companies utilize kaizen at a regular cadence to drive continuous improvement.
15. Successful lean companies utilize appropriate metrics and visual management to drive lean improvements.

Culture

16. Successful lean companies have their own version of the Toyota Production System (TPS) that is not just a document, but a significant part of the company's culture.
17. Successful lean companies recognize that developing a lean culture is a lengthy process and that lean is never-ending.

Appendix 2 - Interview template

Initial Questions

Can you briefly describe your role at Gunnebo?

Can you describe what has changed in your department since the Lean initiative started?

What does Lean mean to the organization and how has it influenced your way of working?

What do you think is the overall feeling of the employees, regarding the changes due to the Lean implementation?

- Can you detect any changes over the last years, regarding employees' mindset towards Lean?
- Has there been resistance towards the proposed changes?

Questions based on the six key constructs of successful Lean improvement by Sisson and Elshennawy (2015).

Deployment

1. (It is driven from the top down. Ask more in detail how the process looked like).

2. Do you feel like the right set of skills exists within the company to successfully implement Lean?

3. Where do you think the main focus of Lean implementation has been on? I.e. manufacturing or non-manufacturing areas?

- In percentage, how would you estimate the division of focus between the Lean implementation in manufacturing and non-manufacturing context?

4. Has Gunnebo tried to extend Lean to its suppliers?

- All of them or just a few?
- How has Lean been received by the suppliers? Positive/Negative?
- What are the plans for continuing these collaborations?
- Will Lean be a new criterion for future suppliers?

Engagement

5. How much time can you devote solely to Lean efforts on a weekly basis?

6. How often is the Lean progress communicated throughout the organization?

- Are you well-informed/updated of what has been changed in other departments?
- Has the purpose and goal of this transformation been communicated well?

7. Do you have any HR policies which supports Lean goals (bonuses based on Lean targets etc)?

- Do you consider to implement any HR policies which supports Lean goals (bonuses based on Lean targets etc)?

Training

8. Have you received any general training in Lean?

9. Will you develop internal Lean leaders and senseis? Explain a little bit about the process of how these were chosen and how they will be trained/developed?

Processes

10. Have you conducted a value stream map?
    - When are you planning to reach future state/desired state?
    - How often is it/ will it be reviewed?
    - Will the map be the decisive factor for choosing improvement opportunities?

11. Are you using standardized working procedures…
    - In manufacturing
    - At office?
    - Who is in charge of updating these when improved standards are identified?

12. a) Have you and your department received a clear task/mission on how to implement Lean?

b) Does every department have a clear task/mission on how to implement Lean?
    - Are all operations within Lean aligned to company goals and Lean strategies?

Drivers

13. What is the driver for your improvements?
    - How often are the VOC gathered?
    - What expected value does the customers receive from the Lean implementation?

14. Where and how often are Kaizen events conducted?
    - Which roles/people are typically involved in these?

15. How is the Lean progress/efforts visualised at office/ in manufacturing?
    - Are there any new metrics to evaluate the Lean progress?

Culture

16. Does Gunnebo have a company vision that embrace Lean as their core values/culture?

- What does it mean for the company?
- Is this used as a reference when discussing strategy or issues?

17. How long time do you think it will take until the Lean culture fully developed in the organization?

Concluding Questions

Do you think that the company has changed over the last 3 years because of the Lean initiative?

What do you think is the best achievement of the Lean transformation so far?

What has been the biggest obstacle during the Lean implementation?

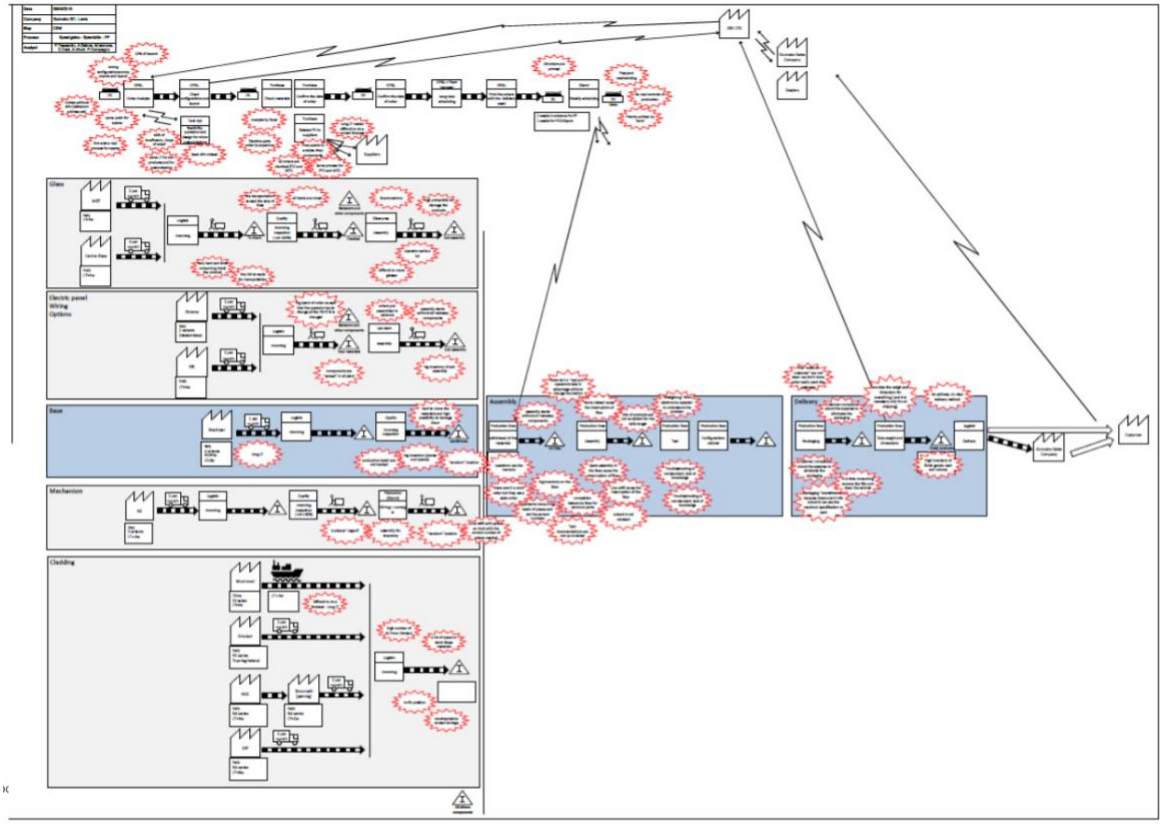
If we would go back in time, would you change anything in order to facilitate the process of the implementation?

- Do you feel like you have the possibility to suggest changes/improvements today?

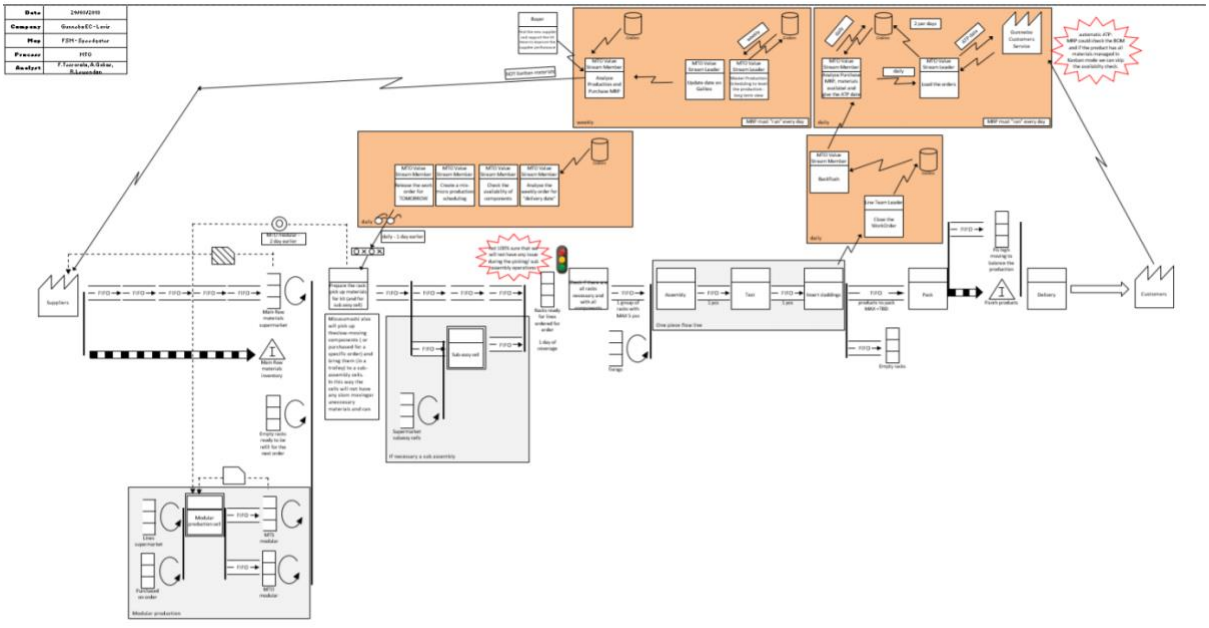
Grazie mille per il tuo tempo!

Appendix 3 - Value Stream Map by Gunnebo

Previous state:



Intended future state:



Appendix 4 - A3 Issue Form for Problem Solving in Line

CELL/LINE:	ISSUE FORM			GUNNEBO
ID	**Short Problem Description**	**Delay (min)**	**Date**	**Initials**
0	*Essemplo: Scratch on tube, had to polish it*	2	11/04	AB

Appendix 5 - A3-Form for Problem Solving

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A3 Problem Solving

With Problem Solving Tools on Back Side

Process:	
Owner:	
Date:	

1) Problem Description - Identify the Problem or Need

Severity (1-3):

2) Goal Statement – Develop the Target State

3) Root Cause Analysis (see back side of this form)

4) Immediate Actions – Solve the Problem Temporarily

5) Brainstorm/Determine Countermeasures

6) Countermeasures Implementation Plan

Actions to be completed	Who	When

7) Check Results – Confirmation of Effect

8) Update Standard Work

What	Accountable	When

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A3 Guide

1) Create a Problem Description by Answering the Questions

What are the effects of the problem?
Where is the problem taking place?
When does the problem need to be fixed?
Why is it important for the problem to be fixed?

Severity 1: Small problem that does not require immediate actions
Severity 2: Impacts the daily operations but is a not a critical issue
Severity 3: Has a major impact on the daily operations and must be fixed immediately

2) Goal Statement – Develop the Target State

Set Specific Goals. Your goal must be clear and well defined.

Set Measurable Goals. Include precise amounts, dates and timings

Set Attainable Goals. Make sure that it's possible to achieve the goals you set.

Set Time-Bound Goals. Your goals must have a deadline

3) Root Cause Analysis (see back side of this form)

Ask why 5 times for:

Why did it occur?

Why has it not been detected before?

4) Immediate Actions – Solve the Problem Temporarily

What was the temporary solution for the problem?
And how did it solve the problem?

5) Brainstorm/Determine Countermeasures

Look back at the goal statement and discuss with as many as possible to find a solution to prevent the issue from repeating.

Write down ALL suggestions.

6) Countermeasures Implementation Plan

Decide from the brainstorming activity:

What action(s) should be done

Who should be responsible for each action

When should each action be fully implemented

7) Check Results – Confirmation of Effect

Use previous measurement to validate that the new solution has improved the situation and that the goal is achieved.

If not, document why and repeat the process from beginning.

8) Update Standard Work

The most important phase. Once the solution has been validated and proven successful, it must be standardized and used by everyone to ensure that the issue will not happen again.