TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

LAURA NIKKOLA-KUUSISTO

LEAN INTRODUCTION VIA PILOT AND TOOLBOX TO GLOBAL FACTORY NETWORK

Master's thesis

Examiners: Professor Kari T. Koskinen,
Dr. Eeva Järvenpää
Examiner and topic approved by the council meeting of Department of Mechanical Engineering and Industrial Systems 13.8.2014

ABSTRACT

TAMPERE UNIVERSITY OF TECHNOLOGY
Master's Degree Program in Department of Mechanical Engineering and Industrial Systems
NIKKOLA-KUUSISTO, LAURA: Lean introduction via pilot and Toolbox to global factory network
Master of Science Thesis, 96 pages, 20 Appendix pages
April 2016
Major: Production Engineering
Examiners: Professor Kari T. Koskinen, Dr. Eeva Järvenpää
Keywords: Lean, kaizen, visual management, value stream

Metso One Factory Initiative management made a decision to implement lean into its processes in order to eliminate waste, reduce lead times and manage all value streams in a more efficient way. In this thesis the initial stages of a lean transformation including pilot projects and lean tools research in Metso One Factory were studied and documented.

Lean tools were researched using many literary sources and their suitability for Metso's purposes was evaluated. Suitable tools were collected into One Factory Lean Toolbox including a summary of the tool's theory and for some tools a template ready to use in practice. Two product groups in need of improvement were selected as pilot projects by upper management and their purpose was to become proof of concept in the lean transformation.

It was found that not all lean tools are suitable for a global One Factory Lean Toolbox because some may be too specific for One Factory's purposes. With the help of a toolbox the selected lean tools are available for all One Factory staff in an easy-to-understand form.
The lean pilot projects revealed many interesting problems and bottlenecks in the process. When these problems were discovered solutions could be drafted and a better flow to the process was achieved. They lead to many big improvements in the order-to-delivery process of the two selected product groups. The project team managed to shorten the lead times, cut the costs, and lower the inventory value. While this thesis was finalized the two factories still have ongoing improvement projects related to the pilots.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO
Konetekniikan diplomi-insinöörin koulutusohjelma
NIKKOLA-KUUSISTO, LAURA: Leanin käyttöönotto pilottiprojektien ja työkalukokoelman avulla maailmanlaajuisessa tehdasverkostossa
Diplomityö, 96 sivua, 20 liitesivua
Huhtikuu 2016
Pääaine: Tuotantotekniikka
Tarkastajat: Professori Kari T. Koskinen, tohtori Eeva Järvenpää
Avainsanat: Lean, kaizen, visual management, value stream

Metso One Factory Initiativen johto päätti ottaa käyttöön lean-ideologian kaikkiin prosesseihinsa. Tavoitteena oli eliminoida tuhlaus, lyhentää läpimenoaikoja ja johtaa kaikkia arvovirtoja tehokkaammalla tavalla. Tässä diplomityössä tutkittiin ja dokumentoitiin One Factoryn kokonaisvaltaisen lean-muutoksen ensivaiheita mukaan lukien pilottiprojektit ja lean-työkalujen arviointi.

Lean-työkaluja etsittiin useista kirjallisista läheistä ja niiden soveltuvuutta Metson käyttöön arvioitiin. Sopivat työkalut kerättiin One Factory Toolboxiin, johon sisällytettiin lyhyt teoria jokaisesta työkalusta sekä käyttöohjeet ja joillekin työkaluille käyttövalmis sapluuna tai kaava. Kaksi erillistä tuoteryhmää valittiin ylemmän johdon toimesta pilottiprojektien kohteiksi ja näiden pilottien oli tarkoitus toimia lean-muutoksen toimivuuden todisteina.

Diplomityössä todettiin, että kaikki lean työkalut eivät ole sopivia globaaliin Lean Toolboxiin, sillä osa niistä on selvästi liian tarkoin rajattuja. Pilottiprojektit puolestaan paljastivat monta mielenkiintoista ongelmaa ja pullonkaulaa prosesseissa. Kun ongelmat tulivat esiin, voitiin alkaa etsiä ratkaisuja ja tavoitella paremmin virtaavaa prosessia. Toolboxin avulla valitut lean-työkalut ovat saatavilla kaikille One Factoryn henkilökunnalle helppolukuisessa muodossa.

Pilottiprojektit johtivat suuriin parannuksiin valitun kahden tuoteryhmän tilaus-toimitusprosesseissa. Projektiryhmä onnistui lyhentämään prosessien läpimenoaikoja, pienentämään kustannuksia sekä alentamaan varaston arvoa. Tämän diplomityön valmistuessa on molemmissa tehtaissa edelleen käynnissä uusia parannustoimia pilottiprojektien tiimoilta.

PREFACE

This thesis process started during the autumn of 2013 while I was already employed at Metso Minerals. The thesis subject was originally supposed to be something quite different but when it came up that my Bachelor's thesis was a study in lean manufacturing and agile manufacturing my supervisors in Metso, Mikko Rontu and Pekka Ahokas, realized that it would be more beneficial to include this thesis as a part of the upcoming lean project in One Factory.

The final examiners for this thesis were appointed in the summer of 2014. They were Professor Kari T. Koskinen and Dr. Eeva Järvenpää. They gave me many ideas to be included in this thesis and Dr. Järvenpää really helped with the thesis structure and making the content seem sensible.

My Bachelor's thesis had given me some insight into lean and its basic principles. That thesis was executed as a study of literature so I already had some good reference material to use as a basis. In this Master's thesis there are two separate parts which were executed very differently. The study of lean principles and different tools and methods was executed mostly independently, and the supervisors from Metso gave comments and basic guidelines to it. They also ordered a couple of books that they wanted to use as the basis of the reference material and the whole study. The pilot projects, however, were much more a group effort. The projects were managed by Pekka Ahokas, and this thesis served as a project resource. I collected necessary data for current state analysis and later in the projects for decision making. I participated in all the steerings and made sure all crucial information was written down and reminded the project teams of upcoming deadlines and all information needed from them. I also took care of other smaller tasks like statistics-making as per the project manager's request.

Writing this thesis took a longer time than originally estimated. The organizational changes in the university affected the schedule a little but mostly it was due to the fact that in the beginning of 2014 I was offered another position in Metso and for the whole spring of 2014 I was doing two jobs at the same time. My current work position has also kept me busy for the autumn of 2014 and only now in the autumn of 2015 and January 2016 I have been able to finish the writing process and finally complete the thesis.

Tampere, 24.1.2016

LAURA NIKKOLA-KUUSISTO

TABLE OF CONTENTS

LIST OF TERMS AND ABBREVIATIONS

5S	A tool of maintaining a clean and orderly workplace and thus increasing productivity and profitability.
5 x Why	A problem solving tool designed to find out the root cause of a problem.
Bottleneck	A phenomenon where the performance or capacity of an entire system is limited by a single or small number of components or resources.
CIP	Continuous Improvement Process, an ongoing effort to improve products, services, or processes.
Concurrent engineering	Designing the product and its production, assembly and distribution processes all at the same time.
C_p/C_{pk}	Process Capability, a simple and straightforward indicator of process capability./ Process Capability Index, adjustment of C_p for the effect of non-centered distribution.
Gemba	A Japanese term meaning "the real place".
ERP system	Enterprise Resource Planning System, usually a computer system which helps with production planning.
Flow	Creating flow will increase profitability by reducing lead times and achieving a pull system.
Heijunka	Production leveling a technique for reducing the unevenness which in turn reduces waste.
JIT	Just in time, producing something only for an actual need, at the right amount and just at the right time.
Jidoka	A compilation of cultural and technical factors which aim towards an approach where people's unique skills are used as efficiently as possible and where machines can control the quality of produced goods by themselves.
Kaikaku	A Japanese term for radical change, it is a business concept concerned with making fundamental and radical changes to a production system.
Kaizen	The practice of continuous improvement.
Kanban	A signboard scheduling system designed for the purpose of achieving just-in-time production.
MRP system	Manufacturing requirement planning, either a software based or manual planning, scheduling, and inventory control system.
MSA	Measurement systems analysis, a specially designed experiment that seeks to identify the components of variation in the measurement.
Muda	A Japanese term for waste.

Mura	A Japanese term for unevenness or inconsistency.
Muri	A Japanese term for unreasonableness or overload.
OEE	Overall equipment effectiveness, a hierarchy of metrics to evaluate how effectively a manufacturing operation is utilized.
PDCA	Plan-Do-Check-Act cycle
Poka-yoke	A Japanese term that means mistake-proofing.
Pull system	A production system where production orders begin upon inventory reaching a certain level,
SMED/OTS	Single-Minute Exchange of Die/One Touch Setups, a rapid and efficient way of converting a manufacturing process from running the current product to running the next product.
TPM	Total Productive Maintenance, a holistic approach to equipment maintenance that strives to achieve perfect production
Value stream	A sequence of activities required in creating a product or service.
Value stream map	A tool for analyzing value streams in picture format.
Waste	All unnecessary and unprofitable actions in a process, waste should be eliminated to create flow.

1 INTRODUCTION

Lean is known as a production philosophy which originates in Toyota Motor Company in Japan. After World War II the directors in Toyota decided to redesign their whole production system because the old mass production methods were proving to be less profitable than before. Toyota's methods proved to be very successful and other companies and American researchers became interested in the story behind this success. This new type of production philosophy became known in the 90's as lean production. The word "lean" is very describing since the basic idea is to eliminate everything unnecessary and unprofitable from the process. Nowadays many organizations around the world are utilizing lean in their everyday actions and making their businesses more successful than ever before. (Hobbs 2004)

Metso's One Factory Lean project began from a will to improve the company's position in different markets. In the constantly changing global market it is no longer possible to compete with the same strategy as before. The customers want the best possible crushing and screening solutions with the lowest possible cost. To meet those needs it is crucial to continue towards continuous improvement and lean can become the driving force in this optimization process. The environment of the industry requires that companies will do more with less so what they really need to do is work smarter, not harder. With nearly three decades of published lean research and multiple success stories all over the world the executive level was eager to see if lean could provide One Factory the way to develop towards the right direction. It became the project team's task to convince them of that.

There is a vast number of lean studies, both theoretical and practical, executed in the world during the last decades. In this thesis only a limited amount of all that information is used mainly because this is only the beginning on the way of becoming a true lean enterprise. In this thesis the basics of lean philosophy will be researched and suitable tools and methods for One Factory selected. Some of these tools and methods would be tested in the pilot projects and, in the beginning, it was hoped that they would be proven effective. This thesis is meant to only serve as One Factory Lean toolbox and database but perhaps in the future Metso might have a lean success story worth benchmarking and publishing.

Selecting and limiting the suitable tools proved to be not as easy as it sounds. There is so much information available that limiting it to a small functioning package was difficult. Also, the more one reads about lean and develops expertise of their own the more difficult it becomes to develop simple introductions for a beginner. In this thesis the history of lean

and the basics of lean philosophy are the key in understanding why lean tools and methods should be used in the global factory network and why and how they can improve the actions executed in One Factory.

This thesis is divided into two separate parts. The lean history, philosophy and lean tools study are purely theoretical research. In chapter 2 a description of the research made for this thesis is explained. Chapter 3 reviews the theoretical background and the basic principles of lean and the history behind lean evolution. It also lists the evaluated lean tools and techniques and gives an insight on how to use them. The practical part of this thesis begins in chapter 4. It starts with an explanation of the project's background and a description of the company's business environment. Chapter 5 includes the contents of the lean toolbox that was created and chapter 6 reviews the progress of the two pilot projects that were initiated at the time of this thesis. Chapter 7 gives some ideas on what the lean management system for Metso One Factory should be like and chapter 8 includes discussion of this project, analysis of One Factory Lean's future and recommendations for further actions. Chapter 9 reviews the conclusion.

2 DESCRIPTION OF RESEARCH

Metso's One Factory initiative recently started a global Lean development project and this thesis was included into that project. It was to become a global project where different locations shared their knowledge and experiences about working in a lean way. The transformation began in Finland where the original project team was located and the first pilot launched but very soon after the initiation also international collaboration was started under the leadership of the Finnish project team.

2.1 Goals of the thesis

The initial purpose of this thesis was to study lean and its multiple tools and techniques and evaluate which ones would be suitable for Metso's One Factory initiative at the beginning of their Lean transformation. After the right ones were chosen they were collected into a compact Lean toolbox available for all participants of this lean project. The toolbox would be located in Metso's Lotus Notes based database. Another goal was to draft a a management system that would be suitable for One Factory Lean. This system would also include a model how best practices of different factory locations become a One Factory standard. Also, a description of how the process is facilitated and managed and how roadmaps are built were meant to be a part of this system. This work was to be done mostly independently under the thesis supervisors. During the process it was decided that drafting a management system wasn't up to the thesis worker and it would take too much attention from the more important parts of the thesis. A model of a management system was to be only a small part of the thesis and not a proper start-to-finish management system.

However, at the same time this thesis initiated it was also decided by One Factory management that the transformation would begin with a pilot project. The second main purpose of this thesis became serving as a resource for that project. It would widen the contents of this thesis to include also practical applications of lean and shift some focus off the original goals, mainly section 3 which refers to the management system. The thesis worker's responsibility was to gather the necessary data, follow up the different improvement projects, update the data, attend the bi-weekly Lean pilot steering group meetings and assist the project manager by acting as the meeting secretary.

The second pilot was initiated a couple of months after the first pilot's initiation and the same tasks applied in that project before the whole second pilot was handed off to the local project team after they got their own Lean Champion candidate to lead the project locally.

The adjusted goals of the thesis were:

1) Selection of suitable lean tools and techniques for One Factory
    a. Writing a short description
    b. Basic instructions
    c. Basic template
2) Compiling the tools into a Lean Toolbox
3) Drafting a model of a management system

2.2 Research methodology

This thesis was executed as a qualitative research project with two hands-on pilot projects as proof of concept. This thesis served as an additional project resource under the projects manager especially during the two pilots. The theoretical background of this thesis is based on the vast variety of material about lean philosophy and its practical use in different industries. Metso's One Factory Lean project's manager had decided to base the starting point of the project on two well-known sources; The Lean Handbook edited by Anthony Manos and Chad Vincent and This is Lean – Resolving the Efficiency Paradox by Niklas Modig and Per Åhlström. The first was to provide usable tools to the project team and the second was to help define the target state.

2.3 Limitations

From the beginning there were some limitation to the approach on this project. The company wanted to determine the main reference material which in this case were the two books mentioned above. So all other material had to follow similar guidelines so they would not contradict the main material. All the tools and techniques used in the pilot projects were selected from The Lean Handbook by the project manager so it was preferable to use it as a source for the whole Lean Toolbox. Also, since the whole lean project had begun before this thesis was initiated, it wasn't possible to start afresh. The conclusions of this thesis would need to be in line with the previous findings and decisions. And since the lean project had its own project manager, it wasn't possible for the thesis worker to act independently on making decision even though many parts of the project and daily tasks were executed in an independent manner.

3 WHAT IS LEAN?

Modig & Åhlström (2013) describe lean as an action strategy which aims towards an efficient flow and to improve efficient use of resources through elimination, reduction and control of waste. According to them, Lean also aims towards continuously improving the flow and resource efficiency.

Originally lean became known as a production model developed in Toyota factory in Japan. A production model means a way of production developed for a certain need or an ideal model of production. Often production models are also known as production philosophies or production methods. The first modern production models were activities and methods designed to meet the needs of mass production and nowadays the world is filled with all kinds of different production systems. The purpose of these systems is to give business management tools for success by developing cost-efficiency and clarifying production activities. (Hobbs 2004)

Throughout history many different production models have come and gone and all of them have been born as a result of the influence of the current era. Early examples are craft production which was prevalent in the pre-industrial world and mass production which followed the industrial revolution. Newer and more modern examples are lean and agile, the latter being developed on the basis of lean. (Hobbs 2004)

3.1 History of Lean

The word lean, in this particular concept was first published in 1991 in "The Machine that Changed the World: The Story of Lean Production" by James Womack and Daniel Jones. The book is based on MIT's five-year study of the future of the automobile industry. (Womack and Jones 2003) However, that was not the first time when this type of thinking and strategy was introduced in manufacturing and business. In order to understand why lean came to be one needs to understand the history behind it.

3.1.1 Mass production

The industrial revolution in the 1860's brought along many changes to production plants. Since then, the industry has shifted towards increasingly larger production volumes and production has become more automated. In 1885, the first publication by Frederick W. Taylor was released. It focused on studying the industrial methods which could increase the efficiency of production. Later in the field of science the concept of Taylorism, or scientific business management was born. In the early 1900's, Ford Motor Company made history by introducing the world's first assembly line production plant which

quickly led to other mass production methods such as standardization and standard products. (Hobbs 2004)

Mass production differs distinctly from the previous small-scale production so naturally the requirements for production planning are very different. Before the industrial revolution production in every industry was smaller-scale because there wasn't enough capacity for larger scale or a clear need for it. When machining in the factories became a reality it was possible to transform production into assembly lines and mass production. With mass production came standardizing in all different industries. The biggest influence was in the automotive industry and arms industry which were driven by the war forces all over the world. (Hobbs 2004)

The advantage in mass production is that assembly lines with large capacity made the products available for customers at a low price. But since the goal of all business is profit this quickly turned to manufacturers aiming for maximum profit. The customer, however, still desires low cost products so the manufacturer needs to cut the costs of production in order to make more profit. This need has generated several different mass production paradigms from which lean manufacturing is just one example. (Hobbs 2004)

The beginning of the 20th century was all about developing profitability and commercializing new innovations. The middle of the century came along with some drastic changes, like the first computer-based MRP systems (Manufacturing Requirement Planning) which are tools for production planning and control as well as batch production. Different batch production methods to optimize production and to lower the costs were developed all through the 60's and the 70's. MRP systems have also been developed further and nowadays ERP systems (Enterprise Resource Planning) are an everyday tool in most manufacturing companies. (Hobbs 2004)

At the same time when the first time MRP systems were being developed in the West, manufacturers in the East, especially in Japan, were studying cost efficiency from a different point of view. The change began in Toyota Motor Company where the management believed that the traditional thinking model of Cost + Profit = Sales price does not work but instead it should be a model based on lean thinking where Profit = Sales price – Cost. In figure 1, the traditional thinking was that the price to the customer was continually increased until the customers started to demand lower prices in the 1990's. Manufacturers couldn't help the increasing prices of materials and labor so the only way to reduce prices was to cut all excess waste from the process, which resulted into lean thinking pictured on the right.(Tapping 2008)

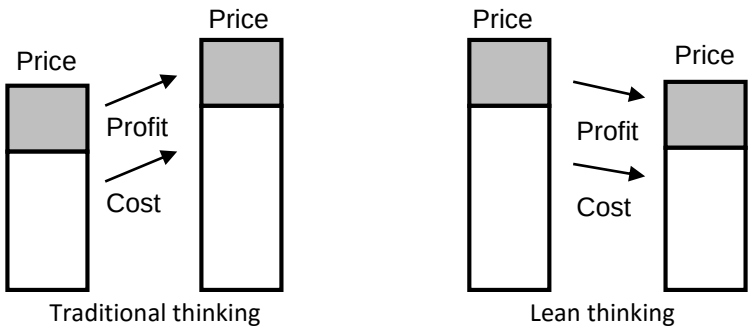


Figure 1. Lean thinking model (Tapping 2008)

3.1.2 Toyota Motor Company

The origin of Lean is traced back to Toyota Motor Company. Toyota production System, sometimes also presented in a very simplified form as Kanban or just-in-time system, evolved out of a need for improvement when the world was going through recession. The development of this system began soon after World War II but the oil crisis of 1973 was when it first became familiar for other manufacturers in Japan. The recession hit hard and companies were struggling with declining demand and zero growth. However, against all odds, in the following years Toyota was making greater earnings than before. That attracted the attention of other Japanese companies. Before the recession the American style mass production method was widely used also in Japan because it seemed that the industry would just keep rapidly growing for the foreseeable future. When recession began the American method was to produce fewer types of cars and still use the same mass production method as before. At Toyota the executives were afraid that the American system would eventually prove to be a mistake. They had no desire to cut back on the models but instead still offer a wider selection of models and produce them in lower quantities. This created the need to cut costs in a different way than the Americans do. (Ohno, 1988)

Based on that idea Toyota began to design a new system which would focus on cutting costs as a priority and getting rid of all unnecessary cost factors. The idea was also that the new system would be able to react to changes in the market environment quicker than the old production models. In the 1980's the Western world discovered that their old production philosophies couldn't compete in the new market and the set targets for profit weren't met. That is why some companies decided to abandon their old production models and move towards the new model that was inspired by Toyota Motor Company. That way they could react faster and achieve smaller inventory, better quality and keep costs under control. (Hobbs 2004) The focus shifted from optimizing individual machines in production to optimizing the flow of the total production process. The new system would also make information management a lot easier than before. (Lean Enterprise Institute 2014)

Even though Toyota started to develop their own, improved production model many of the basic ideas came from American companies. Ohno (1988) states that many management techniques related to quality control and industrial engineering were imitated from the Americans. Before World War II there were people saying that American and German workers were many times more efficient than Japanese workers and at the same time the management at Toyota were setting very ambitious goals for the future. According to Ohno, this was the starting point of a new Toyota production system.

In the 1980's Toyota attracted interest in the eyes of the western world when people discovered that the Japanese cars were longer lasting and less defective as American cars. It was clear that the Japanese were doing something right. There was a certain consistency in the process and products with which the Americans couldn't compete. And somehow all that didn't reflect on the price. Whenever a competitor was threatening the market share of Toyota, they very quickly reacted to the change and came back with a clear improvement. (Liker 2004)

Nowadays Toyota is close to becoming the biggest auto manufacturer in the world based on overall sales. It is also a leader in new hybrid technologies and it dominates many market areas in the world. Its continuing success is the biggest proof of the power of lean production and most of all lean enterprise. (Lean Enterprise Institute 2014)

3.2 Lean production system

Lean is often known only as Lean production system or Lean manufacturing. It is usually described as a series of different actions which one can combine and tweak and eventually eliminate all seven types of waste from manufacturing. When those are eliminated the result in improvement in quality and a decrease of production cost and time. (Wilson 2010)

James Womack and Daniel Jones were touring Japanese companies in the summer of 1982 trying to understand the reason behind their success. They found what they were looking for in Toyota. They created value for the customer by performing a series of actions in the correct sequence and at the right time and by doing them properly the first time. It took years of studying but finally in 1990 they described the process in their best-seller *The Machine That Changed the World*. The book described in detail the way of lean production that made Toyota superior compared to other companies in the auto industry. The next step was to expand the view beyond auto industry and describe how other industries can use lean to improve. (Womack and Jones 2005)

Lean Production System can also be put in a picture form presenting a house, like in figure 2. This House of Lean describes the way a lean system is built from the bottom up. On the bottom there's the basic foundation of lean, the pillars include the useful lean tools and the roof contains the key objectives of a lean business. However, this picture is

only a very simple representation of a lean system and it doesn't give any answers to how lean works in everyday working environment or how it can be effectively exploited. To understand the House of Lean one needs to thoroughly understand the concepts mentioned in it and master the use of lean tools. (Wilson, 2010) In this thesis most of the terms and concepts presented in the House of Lean will be introduced and explained.

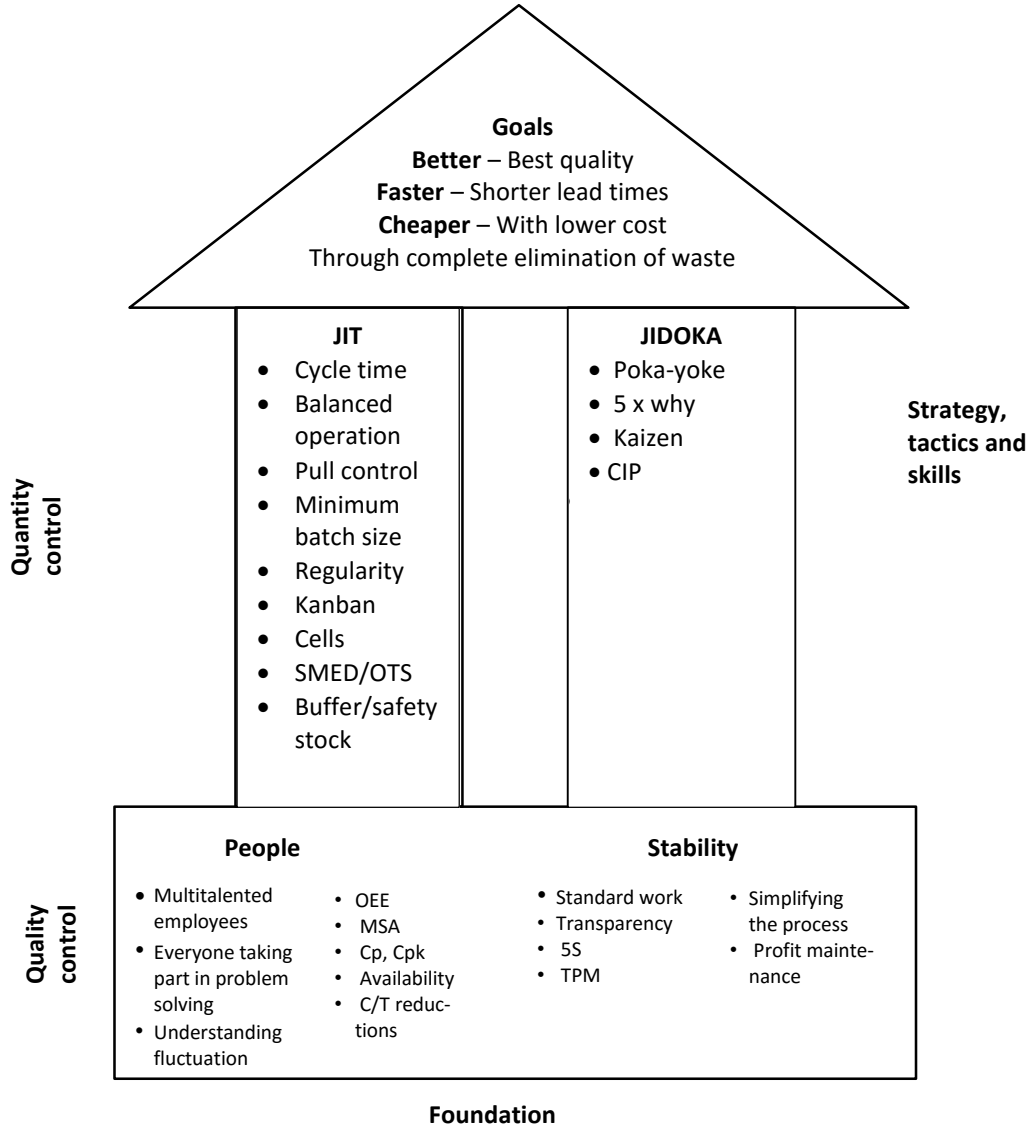


Figure 2. A House of Lean (Wilson 2010)

3.3 Principles of Lean

Different Lean experts and authors each have their own opinion of what the principles of Lean actually are. Each source presents a different point of view and emphasizes a certain thing to be the most important aspect of Lean. This chapter presents a few of those opinions.

Lean is an English word meaning thin, slender or even poor. The name lean is quite appropriate because properly implemented it trims the process from all unnecessary factors.

With Lean the process can function with lesser material, physical space, inventory and people and at the same time require lesser investment. The cornerstones of Lean are JIT (just in time) and *Jidoka*. JIT means producing something only for an actual need, at the right amount and just at the right time. *Jidoka* is a compilation of cultural and technical factors which aim towards an approach where people's unique skills are used as efficiently as possible and where machines can control the quality of produced goods by themselves. A lean process is also known for its easy predictability and smooth fluency which are combined with the term *flow*. Basically by implementing Lean an organization can eliminate unnecessary uncertainty and confusion from its processes. (Wilson 2010)

3.3.1 Lean culture

The basis of a Lean organization is a Lean culture within the organization. Culture includes all the behavior, relationships, comprehension, and interaction between individuals and teams within an organization. With a Lean approach it is possible to gain better quality and productivity, minimize costs, create more value for the customer and eliminate waste. Lean philosophy and culture consist of all the knowledge, tools, and techniques that can be found in an organization. Human factors are always behind a successful Lean transformation or culture. The change begins with people's behavior and attitude. (Manos et al. 2012)

Toyota's organizational culture is a people-centric culture and is what Lean should be all about. It is important to find the right people in the organization in order to achieve this type of culture. They need to be competent, willing and able to go forward with this transformation. Lean training and influencing the way people interact within the organization should begin as soon as new people are hired. The measured key performance indicators should be clear on all levels of the organization so that the target is well known and communicated to everyone. Every level also needs training in problem solving methods suitable for their position and continuous improvement should be implemented as a part of the daily routines. When the Lean culture evolves a certain group of people will advance to the position of a leader who will continue to teach and fully understand the organization's Lean philosophy. It is important to recognize the top performers and rewarding their hard work as well as to offer help to those who are finding it somewhat harder to succeed. (Manos et al. 2012)

3.3.2 Understanding value

Lean Enterprise Institute starts from the value point of view and it describes the principles of Lean as a continuous five-step thought process where different Lean techniques are implemented in different steps. This is pictured in figure 3.

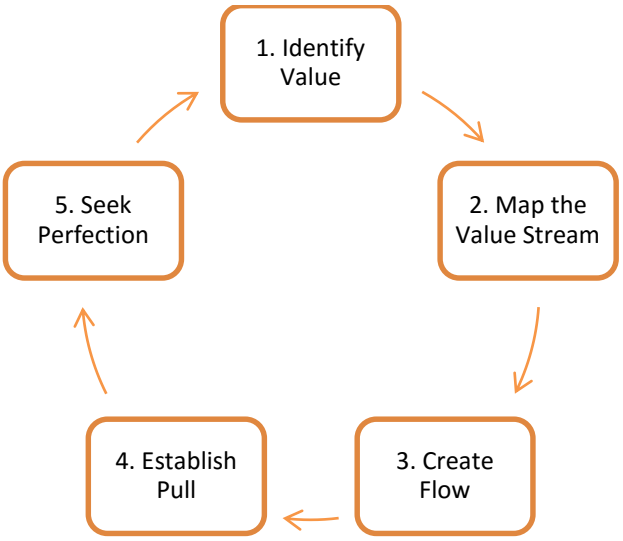


Figure 3. Five-step thought process (Lean Enterprise Institute - Principles of Lean 2009)

To better explain the process the necessary steps are listed below:

1. Identify the product's value from the standpoint of the customer.
2. Determine the steps in the Value Stream which create value and eliminate the non-value adding functions.
3. Create a smooth flow by arranging all the value adding steps as a tight sequence.
4. Establish pull so the customer is able to pull value from upstream activities.
5. When the previous steps have been achieved commit to seeking perfection by beginning the process again. Assuring continuous improvement is the way to seeking perfect value and zero waste.

Kouri refers to the same five steps in his lean pocketbook. He explains that in practice steps three and four usually mean a new layout and implementing a new control model in production. Workstations are cleared up and their efficiency improved. In the next stage a systematic problem solving system is initiated and target indicators are brought to the workstations. Kouri also suggests that it would be wise to develop the process by thinking of the other departments as internal customers and creating value for them. (Kouri 2010)

Modig and Åhlström (2013, p. 99) state that there are so many different books written about lean and so many theories presented that it is easy to get confused about what lean really is or what it means. They decided to describe lean in a new way and they call it an efficiency matrix. This matrix can be seen in figure 4.

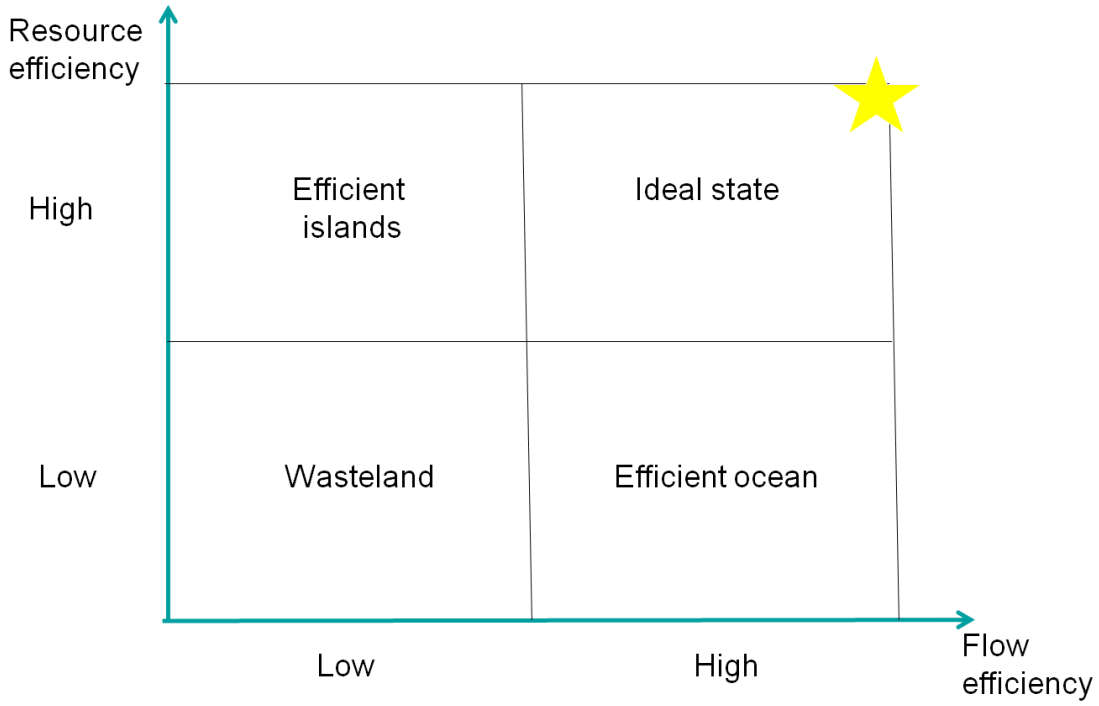


Figure 4. Efficiency matrix (Modig & Åhlström 2013, p. 101,103)

This matrix shows how an organization can be categorized based on two qualities; resource efficiency and flow efficiency. Resource efficiency means the efficient use of the resources available. The simplest way to describe it is to state that productions machines are the resources and when the machines are used as much as possible in the given time it can be seen as efficient use. When the machines are left unused often or they can't be used at the same time it is inefficient use. Flow efficiency refers to the effective flow of a processing unit. If it smoothly flows through the process from beginning to end and all the while value is added to it the flow efficiency is high. However, if it's often left waiting or somehow sidetracked the flow is not efficient at all. Those two are then divided between high and low efficiency. The matrix has four sections in which an organization can be placed. The left upper corner is a place where there are efficient islands. They have high resource efficiency but low flow efficiency. This type of organization consists of partially optimized particles which independently aim towards maximizing their resource efficiency at the expense of the flow efficiency. In manufacturing that means that each individual component or part spends most of its time in storage. The right lower corner is a place called efficient ocean where resource efficiency is low and the flow efficiency high. This requires a proper understanding of the whole process unlike the previous section with only efficiency islands. The main focus lies with the customers and their needs being fulfilled as soon as possible. Wasteland is situated in the lower left corner and it is an unwanted place for any organization. It is a place where resources are being wasted, flow is weak and the value received by the customer is at a low level. The upper right corner is the section called ideal state. If an organization reaches that place it has high

resource efficiency as well as high flow efficiency. This place is very hard to get to and the main reason for failure in variation in the process. (Modig and Åhlström 2013)

The optimal place to be in the matrix is the peak of ideal state, the furthest point in the upper right corner marked with a star. Unfortunately, that is only possible to reach in theory. It would require a perfect understanding of a customer's current and future needs and a perfect resource flexibility to be able to fulfill the customer's needs without delay. The organization should in theory be able to forecast what is needed, when the need arises and what amount is needed. Because that is impossible the organization needs to make certain strategic choices to define where in the matrix they want to be situated. (Modig and Åhlström 2013)

The main idea behind the matrix is that lean is actually an operating strategy for an organization. The strategy that defines where they want to end up in. In order to execute the strategy there are four groups of ways that can be drawn into a hierarchy pyramid like in figure 5. On the top there are values, which describe what the organization should be like. Principles define how the organization should think. Methods define what the organization should do and Tools & actions define what it should use. The two highest levels are the abstract change in an organization. The two lower levels are the concrete change where these things are actually executed. When the organization thinks of these as ways to implement their strategy they can put the purpose of lean, which is eliminating variation, into action. With values they can reduce variation in employees, with principles they can reduce variation in the way the employees think, with methods they can reduce variation in what the employees do, and finally with tools and actions they can reduce variation in what the employees use. (Modig and Åhlström 2013)

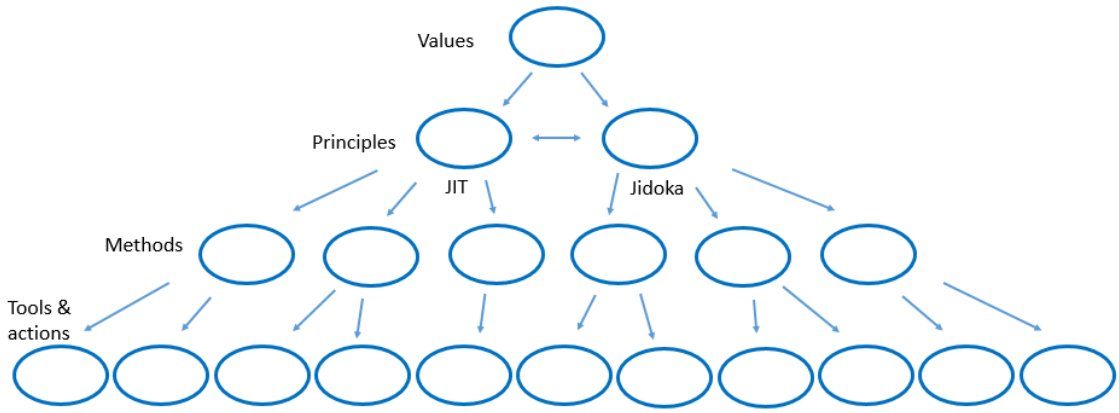


Figure 5. Lean pyramid (Modig and Åhlström 2013, p.138)

3.3.3 Lean management

A Lean culture is completely dependent on the support from the top of the organization. The top executives and leaders must be strongly committed to making the Lean transformation and steering the organization forward with persistency. The leadership is the key

enabler in establishing a Lean culture. The vision and mission need to clearly set and also communicated to employees in order for them to adopt the Lean culture in their everyday actions. Good leaders also understand that in a Lean transformation continuous success is impossible and that failures are inevitable. And when a failure is encountered it is important to not focus on placing the blame on someone but rather focus on finding the root cause of the failure, whether it is a system, process or human failure. (Manos et al. 2012)

In his book, *The Toyota way*, Liker presents 14 management principles that he observed while studying Toyota. The goal of the book is to explain what has made Toyota so successful and what other managers should learn from them. The 14 principles are:

1. Base your management decisions on a long-term philosophy, even at the expense short-term financial goals.
2. Create continuous process flow to bring problems to the surface.
3. Use "pull" systems to avoid overproduction.
4. Level out the workload (*Heijunka*).
5. Build a culture of stopping to fix problems, to get quality right the first time.
6. Standardized tasks are the foundation of continuous improvement and employee empowerment.
7. Use visual control so no problems are hidden.
8. Use only reliable, thoroughly tested technology that serves your people and process.
9. Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.
10. Develop exceptional people and teams who follow your company's philosophy.
11. Respect your extended network of partners and suppliers by challenging them helping them improve.
12. Go and see for yourself to thoroughly understand the situation. (*Genchi Genbutsu*)
13. Make decisions slowly by consensus, thoroughly considering all options; Implement decisions rapidly.
14. Become a learning organization through relentless reflection (*Hansei*) and continuous improvement (*Kaizen*).

Liker (2004, p.69) has developed another type of pyramid model which is shown in figure 6. The first and most important principle, according to Liker, is basing all important decisions on a long-term philosophy and that is why it is the basis of the pyramid. The second step is Process and it includes principles 2-8 which are all related to process design and accomplishing a perfect flow to the process. The third step is People and Partners and it includes principles 9-11 which are all about adding value to an organization by developing people and partners and the relationships between the three parties. The top of the pyramid consists of principles 12-14 which concentrate on problem solving. They are all

about finding the root problems and solving them and thus driving the organization towards learning. (Liker 2004)

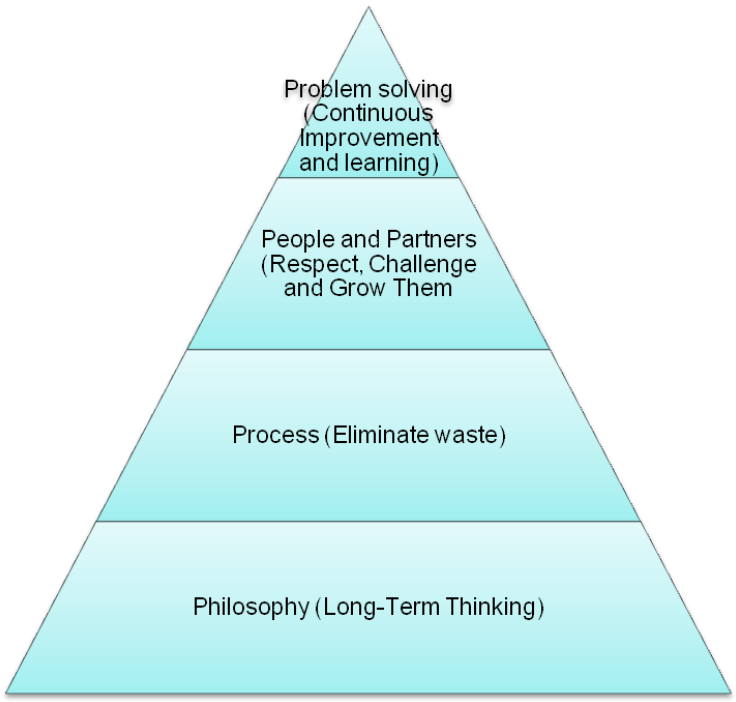


Figure 6. The Toyota Way Pyramid (Liker 2004, p. 69)

3.3.4 Flow

Before Toyota Production System the traditional way of looking at the flow of a process was from the start to the end. The materials would flow from the first process stage to the next and the next after that until they are built into a finished product. What changed at Toyota was the way of looking at the production flow. The thought was what if a later process stage goes into the earlier stage to pick up just that one part just at the right time and quantity. That would mean that the earlier process should produce only the needed amount of part at a certain time. (Ohno 1988)

The important thing is to focus on the actual object that is moving through the process. In service industry, that object can also be an order, a design, or even a person. That object must be guaranteed a flow without impediments. That is why all machines and workers must be in proper working condition. In flow systems either everything works or nothing works, there is no half-way. The workers need to be cross-skilled to make up for one person missing, the machines must be 100 % available at the needed time and the raw materials need to be in proper condition. (Womack et al. 2003)

It is easiest to picture a working flow for a manufacturing line where actual products make their way downstream. But is shouldn’t be that difficult to apply that flow into different

processes by thinking outside the box for a while. By using lean thinking it is possible to see opportunities for achieving flow elsewhere. (Womack et al. 2003)

3.3.5 Pull control

According to Liker (2004) pull control is the ideal state in just-in-time manufacturing which is giving the customer what they want, when they want it, and in the desired amount. The leanest example of this kind of pull would be a one-piece flow where only one product is manufactured based on customer order. That way there's zero inventory and 100% on-demand.

Pull control means that in a value stream no one upstream should start producing anything until it is requested by the customer who is all the way downstream. The big idea is to not make anything until it's needed and when it's needed then make it quickly. Pull control and flow go very much hand in hand and ideas support each other. Enabling a flow in the production stream where the customer pulls value from its source in the way of reaching perfection. (Womack et al. 2003)

The objective of all lean actions is the ability to operate in a just-in-time (JIT) way. With JIT it is possible to eliminate the worst of the 7 wastes which is overproduction as well as unnecessary fluctuation. JIT can be achieved and sustained by putting to use some of the best practices which are continuous flow, *kanban* (signboard scheduling system), and *heijunka* (production leveling). (Manos et al. 2012)

3.3.6 Muda – 7 wastes

Muda is a Japanese word that means waste. It can be defined as all those usually human activities which create no value (Womack et al. 2003). According to Manos et al. (2012, p. 53) there are three components of which work consists of:

1) Actual work which is value adding to the product or service from the point of view of the customer.
2) Auxiliary work or incidental work which is an activity that doesn't add value for the product or service but is necessary.
3) Muda or waste that is an activity that doesn't add value and is unnecessary.

Ohno (1988, p. 19) presents that the equation

$$Present\ capasity = work + waste \qquad [1]$$

is true for both an individual worker and an entire line. True efficiency is only achieved when the percentage of work is 100 and the percentage of waste is zero. Despite of this there are a couple of other things one should keep in mind. Improving efficiency is reasonable only when the result is cost reduction. This can be achieved by producing only the necessary things with minimum manpower. The other thing is that efficiency needs to be studied as a whole beginning from the individual worker and ending with the whole factory. When efficiency needs to be improved it must be done simultaneously for each step so the efficiency of the entire factory is improved. (Ohno 1988)

Tapping (2008, p. 10) defines the term *muda* and the seven wastes originally listed by Taiichi Ohno as the following:

1) Overproduction

   Overproduction is usually the biggest of the seven wastes. It means that a product or service is manufactured before there's an actual need for it. Often it also includes other types of waste.

2) Waiting

   Waiting in itself is a waste. Waiting can include waiting for people, information or e.g. signatures and it happens all too often in organizations.

3) Motion

   Motion as a type of waste includes e.g. motion of people, papers, emails and all other motion that creates no added value. Reasons for this waste are usually poor office/production layout, inefficient equipment and positioning tools and equipment too far.

4) Transportation

   Unnecessary transportation is something that is present in the whole duration of the production process. It affects every product or service's internal and external deliveries.

5) Over-processing

   Over-processing is an activity where such resources which the customer (internal or external) does not require are used in manufacturing the product or service.

6) Inventory

   Excess inventory means work piling up somewhere in the process and also excess time and supplies. They take up physical space and time and sometimes

parts, supplies, and semi-finished good even become outdated if the customer requirements change.

7) Defects and re-work

   Defects is a simple type of waste to understand. It includes all the work it takes to rectify mistakes. Defects cause additional administrative processes which create no added value for the product or service.

8) Tapping (2008, p. 10) defines also an eighth type of waste. It is the underutilization of people. Sometimes organizations make the mistake of not utilizing peoples' skills and know-how and that is of course a waste of resources.

In the next figure no. 7 are the seven types of waste compared to value adding activity in a general case according to Tapping's experience. This indicates that there are usually a lot of possibilities of eliminating different wastes in a general manufacturing situation.

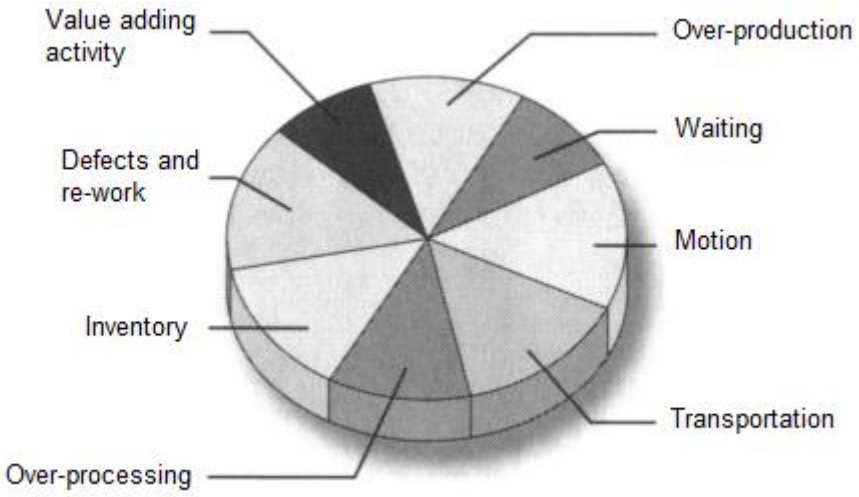


Figure 7. The types of waste compared to value adding activity (Tapping 2008)

The first important thing in lean is to understand *muda* i.e. the seven types of waste and their elimination as a way to success. After *muda* the next important term is *mura*. *Mura* can be translated in English as unevenness or irregularity. The basic idea is the same as in quality management's six sigma tools where all unevenness and irregularity needs to be eliminated from the process. The idea is based on the process becoming more easily controlled and managed when there's as little unevenness and irregularity present. (Hines et al., 2011)

The third similar term is *muri* which in lean means unreasonableness or to make it simpler, overload. *Muri* is often caused by unevenness which leads to too much workload and simultaneous tasks piling up on one person. Usually the reason is that old work procedures and their rationality are not questioned by anyone and the organization just keeps going and doing things like it has always done. Compared to the other two terms, *muri* is often very simply eliminated but for some reason it is left with lesser focus. Nevertheless, the goal is to achieve to eliminate all three. (Hines et al. 2011)

3.3.7 Heijunka

Heijunka is a Japanise term meaning production leveling. Unlike in mass production where huge lot sizes are considered the optimum in *heijunka* the goal is to reduce lot sizes to a minimum. This affects the actions of the upstream processes and they have to adapt to a schedule where many more changeovers are required. For this reason the changeovers have to be executed very quickly so that the whole process stays flexible and production stays leveled. This method of production eliminates significant peaks and valleys and results in fewer adjustments and less strain for all the involved parties whether it be equipment or the employees of a production company, suppliers, or customers. (Manos et al. 2012)

3.3.8 Jidoka

Another important pillar of Lean is *Jidoka* which is often translated as "autonomation". It means automation that can think with a human mind. The purpose is to be able to stop work automatically if some sort of a defect is detected. It combines the techniques of automation and mistake-proofing. Systems and machines that can achieve this have been in use since the beginning of the 20th century when the world really changed into industrialized society. One of the main goals is to reduce costs by not letting defects go through the whole process but instead stopping the process immediately. (Manos et al. 2012)

3.3.9 Kaizen – Continuous improvement

The word *Kaizen* first became known to the western world in 1986 when the book *Kaizen: The Key to Japan's Competitive Success* was published. In 1993 the *New Shorter Oxford English dictionary* decided to define kaizen as an English word meaning "continuous improvement of working practices, personal efficiency, etc., as a business philosophy". Kaizen focuses on improving processes but in order for it to work it requires the dedication of everyone involved in the process. Both managers and workers need to be on board with the kaizen philosophy. One of the best parts of implementing a kaizen process is that it rarely requires large monetary investments, the change comes from within the company. (Imai 2012)

According to Imai (2012, p.4) the first step in implementing a kaizen process is to establish a plan-do-check-act (PDCA) cycle to ensure the continuation of sustaining and improving standards. PDCA cycle is pictured in figure 8. Imai also claims it is one of the most important concepts on the kaizen process. Plan refers to the targeted situation which should always be determined in a kaizen environment. Do refers to implementing the improvement plan. Check refers to evaluating if the improvement plan stays on track and if targeted goals are met. And act refers to standardizing the new procedures to help prevent the original problem.

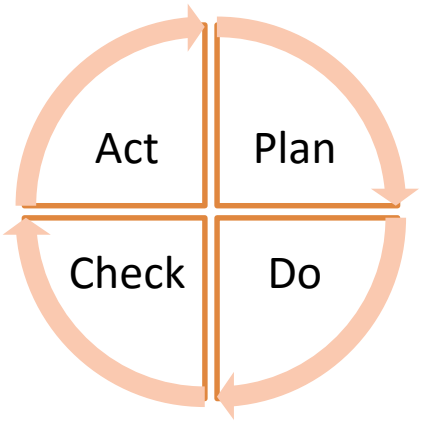


Figure 8. PDCA circle (Tapping 2008)

Tapping (2008, p. 17) describes the often used PDCA circle's four steps in a more detailed way:

Plan	Recognize and analyze the existing problem
Do	Develop a solution model and implement it
Check	Evaluate results
Act	Depending on the results adopt or update the necessary requirements, reject the developed model or go through the PDCA circle again

Another kaizen cycle is the standardize-do-check-act (SDCA) cycle. That means a process where a current work process is first stabilized before taking on action with the PDCA cycle. Any time an abnormality is detected in the process it is important to estimate if it was caused by a lack of a proper standard or not following the standard. Before the current process is stabilized the use of PDCA seems rushed. (Imai 2012)

Another method often used with Kaizen is the 5 times why (5 x why) method. Tapping (2008, p. 66) tells that it is a method where asking the question *why* several times to find the root cause of a problem by studying the cause-effect relationship. Sometimes it takes only two questions to figure out the problem and sometimes it takes five or even more.

Hines et al. (2011, p.6) state that often the use of 5 x why method leads to the discovery of *mura* being the cause of *muda* in the process.

Poka-yoke can be translated into English in two separate parts, *poka* means an unintentional error and *yoke* means avoiding. Thus the purpose of *Poka-yoke* is to avoid unintentional errors. Tapping (2008, p. 90) describes *poka-yoke* as a method which includes all the measures, people's control and various automatic alerts which prevent errors or, alternatively, when an error occurs make it easier to detect. The fundamental idea is that the cause of an error in a product produced by the process is an error in the process itself.

The acronym CIP is often used in lean literature. It means *Continous Improvement Process/Philosophy* and it literally means a process or philosophy that aims towards continuous improvement. CIP is often hard to measure comparably and it's not easily presented in any kind of chart or a diagram but if one is dedicated enough to the issue it can be done. The fundamental idea behind CIP is to reflect on one's own process and through that get necessary feedback of its efficiency. It also helps people to recognize the less optimal processes that weaken efficiency so that it will be easier to eliminate those fully from the process. CIP also advances the process evolution even though usually only in small steps instead of giant leaps. (Wilson 2010)

Liker (2004, p. 278) presents a *Kaizen* workshop. A team begins the workshop by defining the scope of the process in need of improving and reviewing the team's objectives. The team members require some training in the basics of lean and the whole objective is to develop and implement value stream maps of the company's processes.

Another term one can run into when studying *kaizen* is *kaikaku*. *Kaizen* is more about small ideas from everyone *kaikaku* is improvement on a much larger scale. It is said that while with *kaizen* the way things are done is improved, *kaikaku* is rethinking the way they are done. (Kaizenworld 2015)

Concurrent engineering is also a concept often mentioned in lean literature. The normal idea in product design is that first one designs the product and its functionality and after that the focus is shifted to designing the production, assembly and distribution processes. Concurrent engineering offers another perspective in product design. The purpose is to design the product and its production, assembly and distribution processes all at the same time. This allows the manufacturer to get the new product to market faster than by using the traditional design methods. Thus, concurrent engineering offers a way to gain significant competitive advantage by entering the market first and to gain a strong foothold before the competitors. (Gunasekaran 2001) The risk in concurrent engineering is that if any one part of the plan fails because of neglect or unexpected changes that failure usually also causes the rest of the process to fail. The designers need to be aware of this risk when they decide to go with concurrent engineering.

Since lean aims to continuous improvement and quality control both should also be reflected in good supplier and customer relationships. Those can be achieved by eliminating waste and seeking improvement in that part of the process. Creating added value for all parties guarantees satisfaction and eliminating waste of time makes real time communication between all parties possible. (Gunasekaran 2001)

3.4 Lean tools and techniques

Even though Lean is much more than a list of tools and techniques there are many of those available that are essential for an organization in their lean transformation. While the main goal is to change the organizational culture the tools and techniques can help in making that change, finding the key factors which prevent change and help tweak and fine-tune the different processes. (Manos et al. 2012) In the next chapters a few of the most commonly known tools and techniques are presented.

3.4.1 Bottleneck analysis

A Lean organization needs to be able to adjust to changes in the environment such as variation in supply and demand. Bottlenecks in any kind of process prevent flow and make planning much more difficult. When thinking about human factors the way to prevent bottlenecks is to ensure the employees are mostly cross-trained. When one part of the process isn't solely governed by a single person that single person's absence doesn't stop the flow causing a bottleneck. When the task can be handled by more than one person no sick leave, vacation, or other absence will critically affect the whole process. Continuous improvement can also be achieved by having a fresh set of eyes taking a look at the task in question every once in a while. (Manos et al. 2012)

When broadening the view outside the human factors a bottleneck is a stage in the process where capacity is less than the demand placed on that stage. Therefore, additional resource or capacity is required. There is a simple formula of calculating capacity. (Manos et al. 2012)

$$Capacity = \frac{Operational\ time\ per\ shift}{Process\ time + \frac{Setup\ time}{Interval}} \qquad [2]$$

That information can be filled out in a process capacity sheet, like the one in figure 9, which gives the capacity for each stage of the process. The stage with the lowest processing capacity per shift is identified as the bottleneck. The sheet is also very helpful when comparing value-added time to non-value added time in each stage. (Manos et al. 2012)

Process Capacity Sheet	Approved by:	Part #			Application		Entered by:	Date
		Part name			Number of parts		Line	

Step	Step name	Machine #	BASIC TIME			TOOL CHANGE		PROCESSING CAPACITY/SHIFT	Remarks
			MANUAL	AUTO	COMPLETION	CHANGE	TIME		
		Total							

Figure 9. Process capacity sheet (Lean Enterprise institute 2014)

3.4.2 Eliminating the 7 wastes by going to Gemba

Waste is the opposite of value. It is an activity which is unnecessary and for which the customer is not willing to pay (Manos et al. 2014). As previously described in chapter 3.2.6, the seven types of waste are:

1) Overproduction
2) Waiting
3) Motion
4) Transportation
5) Over-processing
6) Inventory
7) Defects and re-work

In Japanese, the word *Gemba* means real place or the place where real action happens and where the facts are. Many business theories in Japan have realized that the place in manufacturing where actual things are happening is an excellent place to make observations and improvements in the manufacturing process opposite to sitting in a conference room and just theoretically assessing the situation. In a business profit related activities usually happens in three fronts; development, manufacturing and sales, which means that *Gemba* can be any of those three sites. (Imai, 2012)

According to Lean philosophy the best opportunity to observe waste is by going to *Gemba*. It is important to understand that the workers in each stage of the process are in the best position to observe and understand what is blocking the flow in that particular part of the process. They also often have an opinion on how to eliminate the type of waste present in their routines. People are the most valuable asset in a Lean organization so

naturally their expertize should be valued and taken advantage of. They must be heard so that the different types of waste can be detected and thus eliminated. (Manos et al. 2012)

3.4.3 5 x why

Five times why is an easy to use lean tool which helps to find the root cause of a problem and to fix it. What is often seen on the surface are the symptoms of an underlying problem. By repeating the question *why* five times (or as long as it takes) will lead to the root of the issue and corrections can be made to the actual problem. (Ohno 1988)

For example:

The machine does not start. (a symptom)

1. Why? – The battery is dead.
2. Why? – The generator is not working.
3. Why? – The drive belt had broken.
4. Why? – The drive belt is a wear part and it wasn't replaced on time.
5. Why? – The service schedule wasn't maintained. (a root cause)

A leader's responsibility is to train efficient problem solvers and decision-makers. Those trained people are equipped with the know-how of identifying potential or actual failures and deducting the root cause for them. A complete 5 x why analysis has three levels which are pictured below in figure 10. In addition to asking *why*, one also needs to ask *what* and *who*. When the root cause has been discovered and eliminated it is very helpful for future reference to gather a "lessons learned database" from all previous failures and their root causes. This prevents others from making the same mistakes again. (Manos et al. 2012)

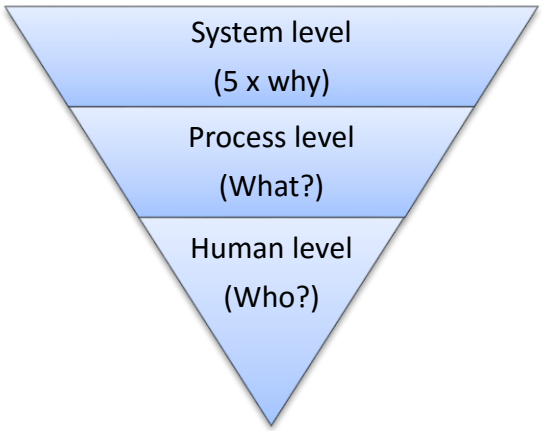


Figure 10. 5 x why analysis (Manos et al. 2012, p. 6)

3.4.4 Value stream map

Building a value stream map begins with defining a value stream. Rother et al. (2003, p. 3) define it in their book Learning to See:

> "A value stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product: (1) the production flow from raw material into the arms of the customer, and (2) the design flow from concept to launch."

The purpose of a value stream map is to help organizations better understand the flow of all materials and information in their process's path from the supplier all the way to the end customer. (Rother et al., 2003)

A current-state value stream map is an easy and visual way on raising consciousness and pointing out opportunities for improvement or countermeasures, as these opportunities are sometimes called in Lean literature. It determines the current conditions of an order-to-delivery process. The basics of the map are pictured in figure 11. (Lean Lexicon, 2014)

Figure 11. The complete value stream according to Lean Lexicon

A value stream map is a perfect tool when an organization wants to take a look at the big picture and to improve the whole process instead of optimizing just small parts of it (Rother et al., 2003).

Also an important part of value stream mapping is defining the target or future state value stream map. It should be based on the same template as the original map and it should define the targeted state of all functions in the map. (Rother et al., 2003)

The point is to come up with ideas that will improve the current state of the value stream. Rother et al. (2003) suggest that because value stream maps can often be very large and complicated it might be easier to break them down into smaller and more manageable bits. When the different bits and subsystems have been identified they can be investigated separately. After that it should be easier to come up with an improvement plan for each separate system in order to reach the targeted goal. These plans should be reviewed and re-evaluated regularly, for example once a year. A new current-state value stream for another current-state analysis can be created when approximately 80% of the improvements or countermeasures have been implemented. (Rother et al. 2003)

One subsystem that can easily be forgotten when focusing on the value stream inside one's own production systems is the value stream from supplier to production company. However, it is an important part of the process and it should be included in the development plan. Liker (2004, p. 199-220) explains how a company should respect their extended network of partners and suppliers by challenging them and helping them improve.

That is why it's so important to involve that part of the process into the value stream analysis and identify the needs for improvement. Involving the suppliers into the development plans will help them commit to a mutually beneficial business relationship and help create a flow throughout the whole process and not just the production company's own part of it.

3.4.5 A3 – project management tool

A3, or like in Japanese *A san*, refers to the paper size according to ISO standard. It is a way of storing gathered information and planning future actions concerning a certain project onto a piece of paper or a one-page document and thus managing that project. The origin on this tool in unknown but it is widely used in Lean project management. In the old days actual A3 sized papers were used but nowadays it is more common to use some sort of computerized version of the tool e.g. Microsoft Excel or Word based A3. The main idea is to keep the description and key points of the project short, simple and easily manageable. At one glance the viewer can observe everything related to the project without having to go through massive amounts of different documents. There is no one right version of an A3 but it usually includes the typical main aspects which are listed in figure 12. (Manos et al. 2012)

Current state and project background	Countermeasures to fix current problems
- -	- -
Goal/Target – future state	Executing countermeasures
- -	- -
Root cause analysis of current state	Creating standards and maintaining them
- -	- -

Figure 12. A3 model (Manos et al. 2012, p. 208)

Just like with so many other Lean tools the main idea behind the A3 thinking process is the journey of learning and discovery. With A3 tool an organization can create a method of problem solving that is precise and thorough, where decision-making and communication is based on actual facts and key information, and where the project group works together in an objective manner. (Manos et al. 2012)

3.4.6 5S methodology

The 5S method is a way of organizing a workplace. The goal is to eliminate waste by having work areas that are neat, tidy, organized, standardized, efficient, safe, and all in

all comfortable to work in. The main idea is to change the workplace into an ideal foundation for implementing other Lean tools and a complete Lean culture. (Manos et al. 2012)

The following table presents the original 5Ss which are five words in Japanese beginning with the letter S. In table 1 they are then translated word for word into English and then converted into similar kinds of English terms starting with the letter s. (Manos et al. 2012)

Japanese	**Translation**	**Conversion**
Seiri	Organization	Sort
Seiton	Neatness	Set in order
Seiso	Cleaning	Shine
Seiketsu	Standardization	Standardize
Shitsuke	Discipline	Sustain

Table 1. The 5S (Manos et al. 2012, p. 105)

Sort

The first word sort refers to all the items found in a workplace. They need to be sorted through and divided into three categories: 1) needed now in the work area, 2) not needed now in the work area, and 3) not needed in the work area. Basically if an item is rarely or never used in a work area it should be removed from there. (Manos et al. 2012)

There's method called 5S Red Tag Technique to help with sorting a work area where the idea is to attach a red tag to an unnecessary item in order to identify it and then transfer the item to a Red Tag Holding Area. The tag should state what the item is, who moved it, the moving date, and the reason for moving it (e.g. not necessary in this work area, or the item is broken). The Holding Area is a temporary place where the items are stored before any decisions are made regarding their future. The items can then, for example, be kept, recycled, scrapped, moved to a work area that requires them, or sold. (Manos et al. 2012)

Set in order

The next step is to take a look at all the items that were found necessary to keep in the work area. All of them need to have a specific location in the work area. If the item is needed daily, it should be easily available, if it's only used every now and then it can be located a little farther away, and if it's used less often it can be located farther away or in another work area. When that reasonable location is decided it needs to be made obvious. There are many different visual aids to be used, such as labels, signs, lines or color coding.

The goal is to set up the work area in a way that anyone can find an item within 30 seconds. (Manos et al. 2012)

Shine

The third step shine does not simply refer to cleaning the work area but inspecting while cleaning. The point is to keep an eye on potential safety hazards, which can be any items or factors that can cause a disruption in the process. It's important to divide the work evenly: who cleans what, when, how, what is needed to do the cleaning and inspection, and how long it should take. The necessary cleaning equipment should be easily available, for example in a movable cart. It's easier to start with big items then move on to smaller ones, and leave the work area floor the last place to clean. (Manos et al. 2012)

Standardize

The fourth step is to create a policy for performing the first three steps; Sort, Set in order, and Shine. It is important to create a policy and rules that can be easily followed. If they are too complicated they won't last very long. (Manos et al. 2012)

Sustain

The fifth step aims at maintaining all the previous efforts. The goal is to create a 5S system that can be implemented as a part of the daily routines. Some organizations offer more 5S training, some try invest in improving communication, some organize audits or benchmarking tours, but for everyone the goal is the same. If the fourth and fifth step are executed poorly the 5S steps will not become routines in the work place and people slip back into their old ways. (Manos et al. 2012)

3.4.7 Kanban

Kanban is a scheduling and controlling system and also the official operating method of Toyota Motor Company. The traditional and most simple form of *kanban* is a piece of paper in a rectangular envelope. The paper contains information about pickup, transfer, and production. (Ohno 1988)

The term *kanban* is Japanese for sign or signboard. In lean it is a signaling method which, in a pull system, gives authorization and directions for the production or withdrawal of items. *Kanban* cards usually state the item name and number, the process of supply (external or internal), pack-out quantity, storage address, and consuming process address. It may also include a bar code to make automatic tracking easier. In figure 13 is an example of a typical lot-making board in which a physical *kanban* is created for each container of parts in the system. Whenever a container of parts is consumed a Kanban card is removed from the container and attached to the board (the blue cards). A white space represents the containers in the system that still have material in them. For each material a certain

number of blue cards triggers a signal to acquire more material containers. (Lean Lexicon 2014)

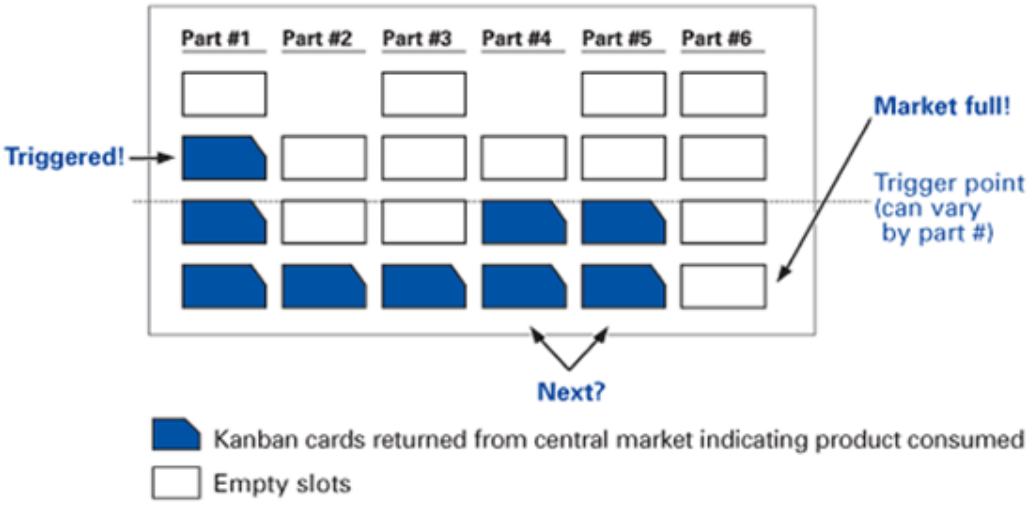


Figure 13. Lot-making board (Lean Lexicon 2014)

There are different types of *kanban* that can be used. Signal *kanban*, which can also be called triangle *kanban*, give a signal to production when the number of containers reaches a certain level. Production *kanban* give instructions to make products, so the upstream process gets information about what the downstream process requires. A withdrawal *kanban* give instructions to material handlers to move products. In figure 14 a type of dual *kanban* is presented. In a signal and withdrawal *kanban* the withdrawal *kanban* gives the authorization to transport parts to a downstream process when the signal *kanban* tells a critical level has been reached. Production and withdrawal *kanban*, like in figure 15, creates a dual *kanban* system in which they co-operate to create a pull system. At the process downstream the operator removes a withdrawal *kanban* when they have taken the first part out of a container. That *kanban* is then taken to a collection box to be picked up by a material handler. Then when the material handler goes back to the upstream process they place the *kanban* on a new container of parts which is then delivered to the downstream process. (Lean Lexicon 2014)

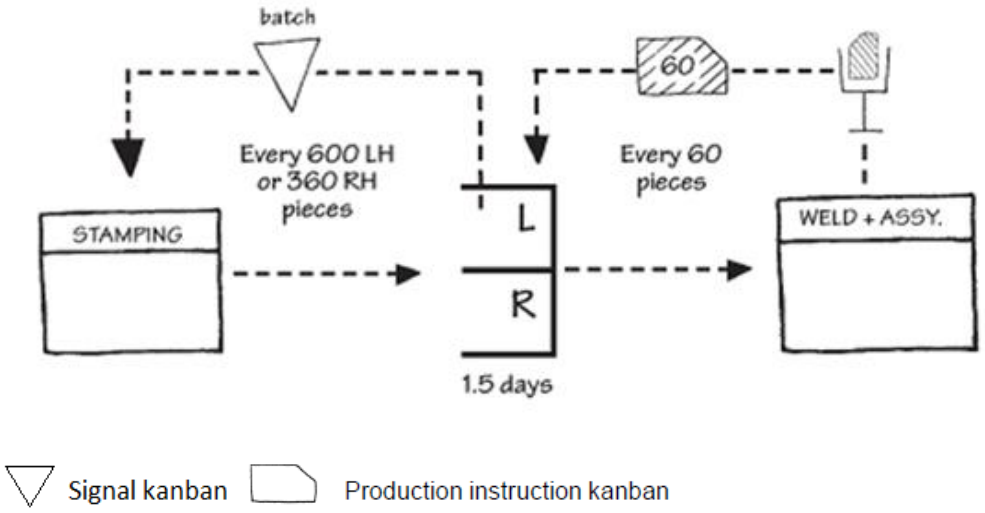


Figure 14. Example of Signal and Withdrawal Kanban (Lean Lexicon 2014)

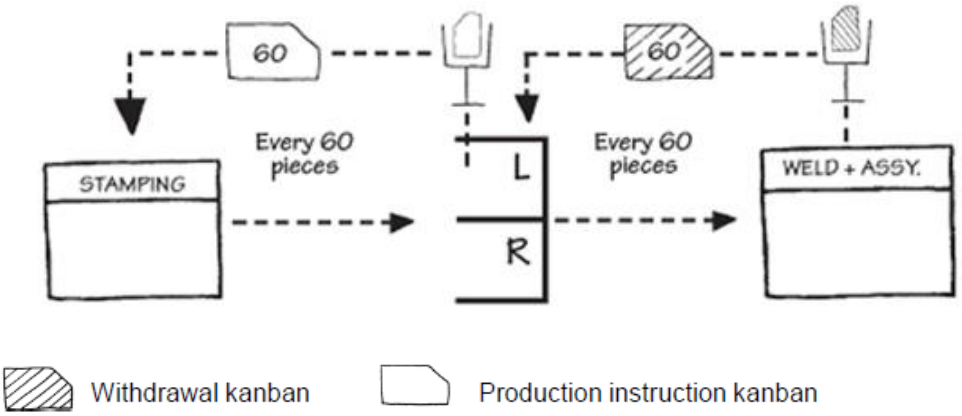


Figure 15. Example of Production and Withdrawal Kanban (Lean Lexicon 2014)

Nowadays, when production systems are often very modern and are controlled by enterprise resource planning (ERP) systems, the *Kanban* sometimes needs to adapt. Electronic *Kanban* or *eKanban* will perform the same tasks as a regular Kanban system, but electronically. The system is programmed to identify the need for a new batch of materials and it will help make sure the flow remains in production. (Manos et al. 2012)

According to Lean Lexicon (2014) there are six key points for using *kanban* in an effective manner:

1. Customer (whether internal or external) processes order materials in the exact amounts determined on the *kanban*.
2. Supplier processes produce materials in the exact amounts and sequence determined by the *kanban.*
3. No products are manufactured or moved without a *kanban*.
4. Every part and piece of material will always have a *kanban* attached.
5. Defective parts and incorrect amounts are never sent to the next process.

6. The number of *kanban* is reduced cautiously to lower inventories and reveal problems.

3.4.8 Poka-yoke – Mistake and error proofing

Poka-yoke is Japanese word meaning "without mistake". It's based on Toyota Production System concept of zero defects. It aims at eliminating the causes behind errors by developing methods of error prevention in processes. In this context it's important to separate errors (mistakes) and defects. Errors refer to mistakes made by people. A mistake can be forgetting to execute a certain part of a task or executing it wrong. Defects refer to a situation where a part or product doesn't reach the level of quality defined by the manufacturer. Defects are often the result of errors but not all errors result in defects. (Manos et al. 2012)

Manos et al. (2012, p. 242) list the three factors which define a *poka-yoke* device:

1) 100% inspection
2) Rapid feedback
3) Low cost and simple

The first, 100% inspection means that every time a part or product is made it should be checked against the standard. That way real-time information about the process and quality is available immediately. If an error is made it can be corrected before it comes a defect and causes problems in the later parts of the manufacturing process. The second is rapid feedback and it links closely to the previous point by allowing an error to be corrected immediately by calling for help or correcting the process in order to get back in actions as soon as possible. This requires that poka-yoke devices are located as close as possible to the source of an error. The third is low cost and simple which refers to the poka-yoke devices. The devices don't have to be costly and complicated in order to work properly. Some of the most effective devices a created with very low cost and very high creativity. (Manos et al. 2012)

Poka-yoke devices come in two types: prevent devices and detect devices. A prevent device is of course meant to prevent the error from occurring. It can be as simple as a cardboard with carefully cut holes in it placed in front of several part bins and the point is that access to the unnecessary part bins is prevented and the only necessary parts can be picked up through the holes in the cardboard. A detect device has the purpose of detecting an error as soon as it has happened and providing a chance to correct it before it becomes a defect in the future parts of the process. It can also be a very simple device that just prevents bad parts from going through. A prevent device should always be preferred in comparison to a detect device but in some processes a detect device is more practical. (Manos et al. 2012)

3.4.9 Quick changeover – SMED

Single-Minute exchange of die (SMED) or quick changeover is another lean method of eliminating waste in a process. The purpose of this method is to significantly reduce the time it takes to switch from producing one product to producing another. It was originally a Toyota consultant, Shigeo Shingo, who came up with the idea that changeovers and setups should take less than 10 minutes (which would equal a single digit). This idea has been developed much further into one-touch exchange of die (OTED) where any change-over or setup should take no more than one minute. (Manos et al., 2012)

The key metric is setup time and that means the total elapsed time between the last piece of one product made by one type of process and the first good piece of the another product made by a different kind of process. The goal is to prevent bottlenecks, produce smaller lot sizes, and increase flexibility in the process in order to be able to offer the customer a large variety of products. Traditional thinking suggest that it would be more economical to produce large quantities at a time but there are a lot of hidden costs (such as storing, counting, moving and scrapping excess materials) behind that kind of thinking. (Manos et al. 2012)

Manos et al. (2012, p. 244-245) suggest that a 5S transformation is a good place to start when trying to achieve quick changeovers. Then all the necessary information, tools, materials, machines, supplies, and setup sheets are available and neatly organized. It is also important to know the difference between internal and external setups. External setups are the tasks that can be executed while the previous process is still running, such as getting tools, materials and documentation, heating dies, and presetting tools. They offer seven key steps for reducing setup times:

1) Go see and document the current condition of setups
2) Separate internal and external setup times
3) Convert internal steps into external steps wherever possible
4) Improve internal steps
5) Document and standardize the setup method
6) Train workers in the new method and hold them accountable for following it.
7) Be on the lookout for additional ways to cut setup time and perform problem solving whenever the standard cannot be followed, costs are rising, quality problems are exposed, or customer conditions change

3.4.10 Visual control

Visual control or visual management is another method of quality assurance in a workplace. The idea is to utilize different kinds of visual tools which help everyone understand the status of the process at a single glance. It also helps managers to estimate whether or not the process is functioning normally. These kind of visual tools vary quite a lot, they can be lines, labels, signs, pictures, painted floors, kanbans, production boards, shadow

boards (a board painted with pictures of the tools that belong there), or many other things. All the visual tools used should be simple enough for anyone to understand by just looking around (Manos et al., 2012)

The goal can be achieving a visual workplace where the work environment is self-ordering, self-explaining, self-regulating, and self-improving. Such a work environment is in order, it explains itself to anyone and everyone in it (what/when/how to do and not to do), is transparent and can regulate itself, and over time can acquire the ability to correct itself. In a visual workplace everything that is supposed to happen does happen, on time, every time, whether it's day or night. (Manos et al., 2012)

3.4.11 Safety and ergonomics evaluation

Safety and ergonomics aspects can be divided into product safety and work safety. Product safety is often regulated by government or other external organizations and it need to be taken into consideration when designing the product. Work safety, on the other hand, aims to improve working conditions, employees' safety and productivity which are all targeted goals in lean. It is the company's job to evaluate all work environments and conditions and identify potential safety issues. They can vary from smaller issues like repetitive motion to life-threatening risks. (Manos et al., 2012)

Safety and ergonomics is very much related in eliminating waste. With eliminating safety risks and interfering in lack of ergonomics a company can get rid of non-value-adding work and reduce injuries, which then lead to money being saved. According to Manos et al. (2012, p. 26) in the safety evaluation at least the following points should be taken into consideration:

- Workplace layout (surfaces, storages, etc.)
- Body positioning when executing tasks (seated, standing, walking, leg positioning, need to reach, posture, etc.)
- Duration of tasks (how often, how long, frequency of changing position, etc.)
- Lifting (how big/heavy parts, how often, etc.)

Proper safety systems in a workplace improve awareness in all personnel. They usually require training, surveys, and designed controls. Both employees and managers are more satisfied to their work environment when through training and awareness the potential hazards are understood, and if possible also eliminated. (Manos et al. 2012)

3.5 Lean implementation

Wilson (2010, p. 135) divides implementing lean into eight steps where steps 1-3 are about evaluating the whole system and steps 4-8 are about evaluating the value stream and its objects.

1) Evaluate the three most important problems in cultural change
2) Run a system-wide evaluation of current production
3) Carry out an educational review of the employees
4) Document the current state value stream
5) Redesign the elimination of waste
6) Evaluate and define goals for this way of operating
7) Enable Kaizen activities
8) After the changes, evaluate current state, strain the system and the go back to step 4

Many different literary sources emphasize the point that lean implementation and transformation begins with people. That is also the case with Liker (2004, p. 290). He stresses that lean implementation should start from the top in order to build a culture from the ground up. There are five important notions in Liker's list of changing culture:

1) Start from the top – this may require an executive leadership shakeup
2) Involve from the bottom up
3) Use middle managers as change agents
4) It takes time to develop people who really understand and live the philosophy
5) On a scale of difficulty, it is extremely difficult

Trying to implement lean without the full commitment and support from the top executives is a waste of time. The goal should be to build a long-term organization that delivers extra value to the customer. This type of ability to make long-term thinking and maintain continuity of leadership shapes a successful implementation of lean in an organization. However, this type of implementation and transformation might take years or even as long as decades. (Liker 2004)

It is important that the strategy describes clearly what you want to do and why you want to do it. When these two questions have been answered you can make people understand the need for change and to concentrate and to invest in it. It is the manager's responsibility to motivate their employees by using speech as well as actions. Motivation can be increased by including everyone in the organization in creating a strategy. The level of commitment is much higher in organizations where everyone feels they have had a chance to influence the process of creating and carrying out a mutual strategy. In order to create a stable lean organization, it is necessary for the manager to aim to an organizational state where everyone knows what is expected of them, everyone feels they are accomplishing something and everyone is aware of what they need to improve. This increases everyone's willingness to make improvements and the working environment and cooperation with colleagues will be more pleasant (Hines et al. 2011.)

3.6 Different stages of Lean

Like previously described, the lean transformation begins with implementing lean tools and methods. They are widely explained in literature and many are fairly simple to use. Methods such as visual management and tools for improving flow make a big difference in the day-to-day actions. However, the biggest reason for failure is that the lean transformation stops here. Methods are important and they should be used throughout the company but more important is the cultural change. Implementing lean methods may lead to short-term success it will soon come to an end without the lean culture to support them (Maskell et al. 2012.)

A lean transformation which aims towards becoming a lean champion can be divided into three steps like in figure 16. According to Frost et al. (2011, p. 2-3) these steps resemble the different maturity stages of sports teams aiming for championship. A company must determine on which level they are playing in order to make a complete analysis of their current situation and pan further improvements for the future.

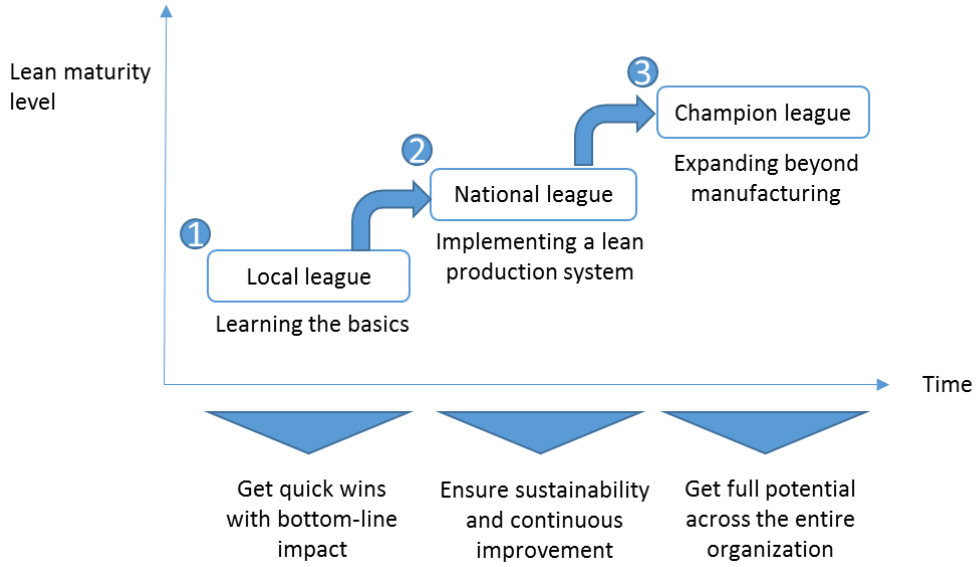


Figure 16. Three levels of expertise (Frost et al. 2011)

Lean Local League is the first step in which the company learns the basic principles of lean. In this stage the organization focuses on trying to find and eliminate waste in production. They know how to start lean projects and use lean tools in individual factories but not necessarily companywide projects in the factory network. Result from similar projects in different factory sites may differ and it is difficult to understand why that is. Usually the people are not fully committed in level 1 even though they have good intentions in their lean transformation. Short-term wins can be possible or sometimes even likely at this stage but the problems begin if the company doesn't move forward from level 1 (Frost et al. 2011.)

The second level is Lean National League where a lean production system is implemented to the whole factory network. They have managed to eliminate waste and thus cutting costs of non-value adding activities. The company has their own toolbox of lean methods which they successfully use at all factory sites. The factory workers have become committed to lean and everyone knows their own lean-related role. Companies on level 2 have often noticed that the money saved by using lean has replaced the money spent on lean projects and actually the projects currently fund themselves without any extra investment. Sustaining the lean production system and being able to continuously improve are the biggest challenges (Frost et al. 2011.)

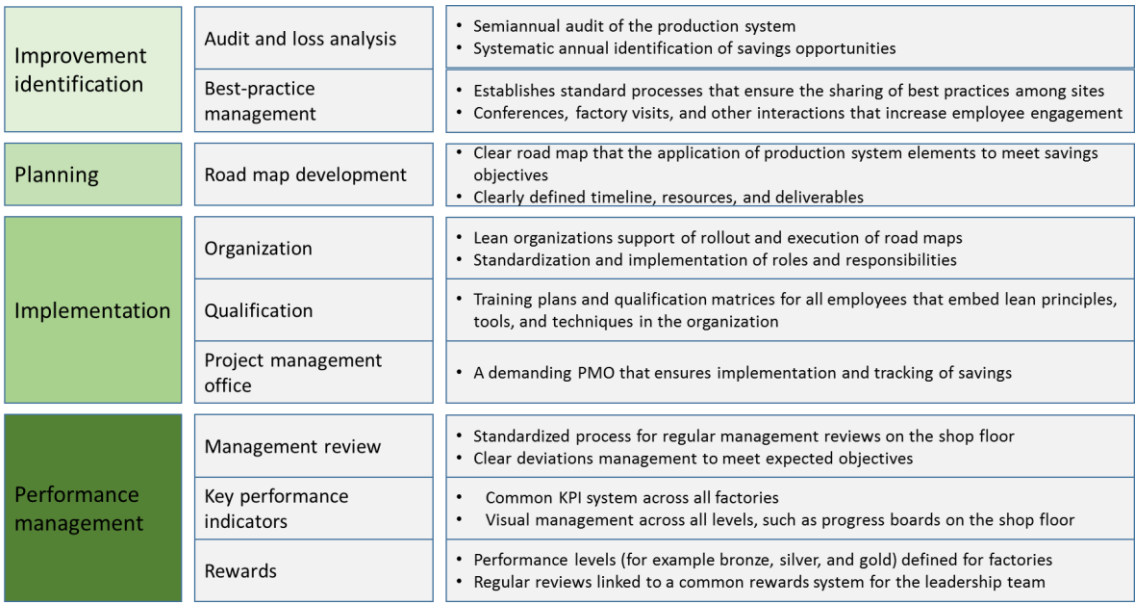


Figure 17. Four components of dynamic governance (Frost et al. 2011)

In figure 17 are the four components in dynamic governance that are required in completing level 2. They are improvement identification, planning, implementation and performance management. Improvement identification means an ongoing activity of analyzing the process and generating ways to eliminate waste. The most successful companies conduct audits on their lean production systems regularly and they share best practices throughout their factory network. They conduct conferences, workshops, and factory visits regularly as a means to improve employee commitment and engagement. Planning means developing new road maps which describe the way of achieving new goals by using lean approaches. Implementation stage is where the company makes sure that the new road maps are supported by the organizations other functions and key people. And again they need to be standardized through the factory network. A project management office monitors the implementation process. The last component is performance management which means managing the whole lean transformation process, measures the key performance indicators, and implements a rewards system (Frost et al. 2011.)

The final level is called Lean Champion League where the target is to expand lean practices beyond production. Implementing lean into functions that don't involve physical products but information flow instead is often more difficult than implementing lean production and that is why there are a lot fewer companies that ever achieve this level. This expanding effort can also be called advanced lean and as such it requires advanced tools. Those tools are sales and operation planning, product segmentation, and bill of processes (Frost et al. 2011.)

3.7 Staying Lean

It is important to separate implementing lean and sustaining the lean system. It is fairly easy to study lean principles and go through PDCA circles once. It is much more difficult to sustain a lean approach and really commit to a lean organization. Lean isn't a simple process one can start and then finish. Its purpose is to stay as an essential part of daily operations and always aim to improving results and successful business. (Hines et al. 2011)

The most common reason for failure is lack of commitment in people, especially the managers. Often people also concentrate too much on different lean and six sigma tools than the lean philosophy itself. Hines et al. (2011, p.10) gives advice on staying lean and keeping lean as a part of all actions:

1) Think of lean more as a philosophy for success rather than a set of different tools and techniques.
2) Spread the lean operating system through the whole organization and not just certain departments to which all the study books refer.
3) Concentrate on improving processes and value streams and not so much on improving departments.
4) Make sure everything you do creates value for the customer, the organization or the personnel.
5) Create your own approach to match your goals rather than copying someone else's.
6) Make sure everyone understands what you are trying to accomplish and why.
7) Align all communication and key performance indicators in order to create and sustain a lean organization.
8) Provide the necessary resources, meaning people and training, for the whole organization and not just the lean coaches you have chosen.

A coherent strategy, vision and purpose need to describe what the company wants to do, why it's important and how to focus the employees change activity. If the employees can't answer those questions they can't be expected to know what to change in their work activities. Figure 18 describes Lean Iceberg Model where, just like in an actual iceberg,

the biggest part of its body is hidden below water level. If strategy, vision, and the management's mission is not clearly communicated the staff they remain hidden and unknown to anyone but the management. In order to sustain lean those things need to be brought to light. Leadership is also one thing easily left below water level because a good leader leads by example. It is the leader's job to inspire other to take part in the lean transformation. (Hines et al. 2011)

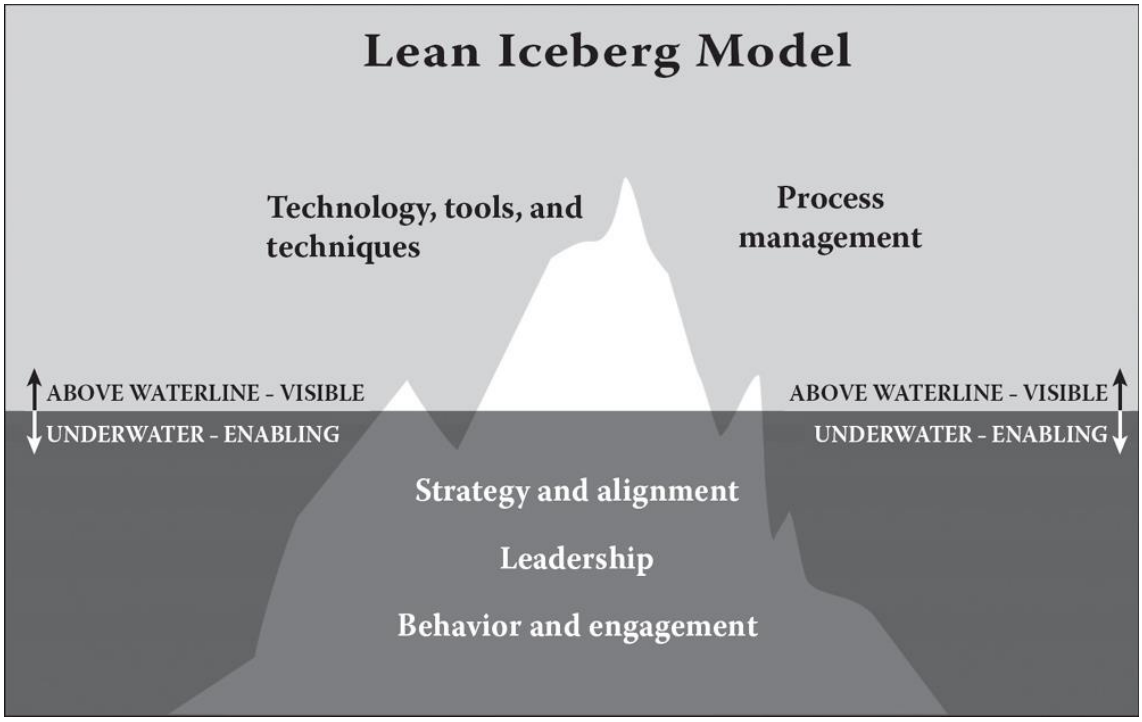


Figure 18. Lean Iceberg Model (Hines et al. 2011)

The reason for failure in lean transformation is always in people. The success depends on people's attitude towards change and their ability to change their behavior in the right direction. They need to be fully committed to the new lean strategy and willing to stay focused on it. The stages of a Lean journey are pictured in figure 19 and they are all related to people in the organization and their perspectives. The picture also lists the main reasons for failure. All of them are reasons solely related to human factors. (Hines et al. 2011)

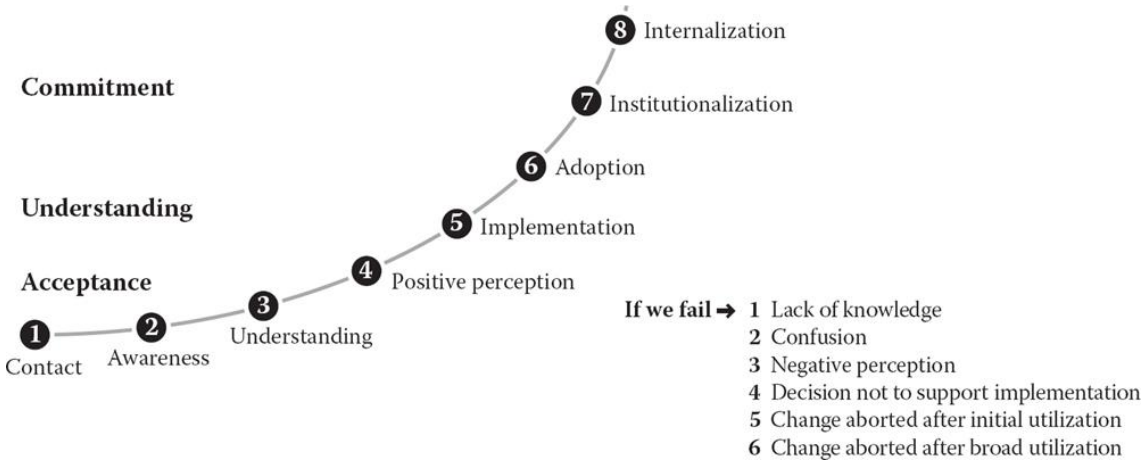


Figure 19. Stages of a Lean journey (Hines et al. 2011)

3.8 Lean office

Especially now that the world is full of different service industries and many people work at an office environment instead of factory floor it is not wise to limit lean thinking only to production. Lean can easily be implemented to other work environments and businesses.

In today's market whether buying a product or a service the administrative processes often take a lot of time. That time and the successfulness of the process defines the level of customer satisfaction. These kind of processes are for example generating a quote or an invoice, entering a customer order, filing an insurance or warranty claim or hiring an employee. These activities represent how a company interacts with its customers and the whole society. In a company that desires success by lean these administrative processes need to be just as well managed with lean as the production is. (Tapping et al. 2009)

There is just as much waste found in an office as there is in manufacturing. Files can be misplaced, finding available meeting rooms can be difficult, right kind of ink cartridges for a certain printer can run out of stock, one person can hoard most of the necessary equipment making others waste time looking for them. All of these things occur regularly in a normal office and all of them can be eliminated. Office work is very often forgotten in improvement projects when all the energy is focused on improving production in the shop floor. The thing to remember is that it is the office the customer first contacts when they are interested in doing business and it is the office the customer is first brought to when they visit the factory site. The work done in the office is a vital part of achieving a profitable business. (Fabrizio et al. 2006)

In a factory it is easy to spot the waste when seeing idle workers and stacks of inventory but in an office it is very easy to miss the signs. Inefficient processes that lack standardization and consistency waste money and other resources and lead to lower customer satisfaction and responsiveness. Human resources are wasted when the time is consumed with tasks that provide less value. The principles of lean production that have lead so

many companies to success can be applied to service processes and office work as well. In the service industry the customer is the product to which value is added when moving through the process. A company needs to rethink the traditional ways working and create new parallel and more efficient processes to improve the value experienced by the customer. (Raj et al. 2012)

Transforming into a lean office might be even more difficult than implementing lean production. White collar workers' resistance towards change is often bigger than the workers in shop floor when it comes to standardizing work. The change starts with doing a complete analysis of the work process and its sub-processes in order to find the problems and bottlenecks. Service workers have a lot of insight into creating customer value so it is really important to involve them in the lean transformation. (Raj et al. 2012)

An important goal in making lean work in an office environment is to link lean directly to the companywide strategy and key business objectives. If lean remains a completely separate effort, it will most likely fail when the staff sees lean as just another tool to be used like a new computer program. If lean is not in line with the strategy the company will never reach its full lean potential. (Rocher 2013)

3.9 Lean company

The usual reason for implementing lean is the hope of improving all processes so that the way value is added also improves. That way both market share and enterprise value should be increased. Lean isn't a simple trick for improving manufacturing. It also can't be a nice looking label glued on top of the company. In order for lean to turn thing around for any company it needs to be the base core for all actions, the strategy for everything. A company needs to be lean, not simply do lean. The main thing is to change the people and the way they act and think. A company must not forget the main focus in their lean transformation which is delivering value to the customer. Many times the focus shifts to merely cutting costs or reducing inventory. (Byrne 2013)

A lean company needs to be lead from the top. A complete lean transformation is usually pretty hard to achieve and it takes a lot of time. Management can't expect it to be a quick process when it can actually take years to succeed and short-term profit might not always be possible to gain. Management should get used to the idea of leading by example and implementing long-term plans for change instead of launching a few quick changes. It needs to be clear that the management is committed and serious about becoming a lean organization. Even the upper management should start getting involved in everyday *kaizen* activities. (Byrne 2013)

Eventually a company that has implemented lean successfully becomes a lean enterprise. There are three typical characteristics of a lean enterprise; lean methods, lean culture and lean relationships. The change usually begins in production where lean methods are used

to create an efficient flow to the shop floor. As improvement is made the changes spread across the organization and there's a need to make a change in the culture of the company. That is because lean methods can't function on their own but they need to be supported by a lean culture. This is often referred to as lean thinking. When things advance even further the need for improving supplier, customer and business partner relationships comes into question. Lean thinking should open up doors for cooperative and mutually dependent relationships with these different parties. This is the way lean production transforms into a lean enterprise. (Maskell et al. 2012)

A lean transformation is really a test for the company's change management abilities. From the top down everyone needs to be involved and feel like they are a part of the change. If the change is done right, lean becomes an inseparable part on the company's culture and the workers start thinking of ways of continuous improvement themselves. (Raj et al. 2012)

Companies must also understand that if they want to move beyond being a lean manufacturer and become a lean company the lean transformation doesn't end at their factory site's border. They need to broaden out their view and widen their value stream thinking. By expanding the Value stream map further upstream to the suppliers and downstream to the customer they will start to see new possibilities for improvement. This process is called macro mapping and it helps the company to work together with its partners to ensure flow and eliminate waste from the whole stream (Maskell et al. 2012.)

4 GUIDELINES FOR CSE ONE FACTORY LEAN MANAGEMENT SYSTEM

In order to stay lean and also fully understand and efficiently use lean CSE One Factory needs a clear Lean Management System. In this thesis the belief is that such a system should be based on and guided by the three fundamental business issues defined by Womack and Jones. Those three issues are purpose, process and people (Lean Lexicon 2014.) It is up to One Factory management team to decide how the lean transformation should be administered and what the northern star for the whole operation is. Ideally, the main focus should be in trying to create perfect value to the customer through a process that creates perfect value and zero waste (Lean Lexicon 2014).

At the time of the completion of this thesis, the pilot projects in One Factory have resulted in many important improvements but what is still lacking is a company-wide management system that is visible to all different levels of the organization. In the production lines involved in the pilots, lean has become a part of the daily operations but it still seems quite unfamiliar to some other parts of the organization. There are departments where the only information about the ongoing lean transformation has come from a single article in the quarterly staff newspaper or a couple of intranet articles.

4.1.1 Purpose

The first issue is the purpose. It should answer the question of what customer problems will the enterprise solve to achieve its own purpose of prospering (Lean Lexicon 2014.) Metso's customers expect the Metso brand to guarantee them the best possible solutions for crushing and screening. Those solutions, however, should not come with a much higher price tag than the competitors' solutions. That is why there's a need to make smarter decisions which cost less money, a need to create a new, unified way of working in One Factory, and guarantee certain Metso standards and quality in each different One Factory location. In today's market the customer needs are constantly changing so adapting to this environment is the key to success today and in the future. The hope is that all this would be achieved by going through a lean transformation and becoming a lean enterprise.

This purpose needs to be clearly communicated throughout the whole company. Every department needs to know what the thought process behind this lean transformation is and what the company is trying to achieve. If the Northern star is an unknown goal and no one knows what is expected of them, how will anyone be able to change their ways of working or the processes they are in charge of. Once again it comes back to the cash-to-cash cycle by Taiichi Ohno. The purpose should be to concentrate on the timeline where

all the money is tied up and make sure that only value adding steps remain and everything else which is defined as waste is eliminated.

Also, if the company is serious about becoming a lean enterprise it includes cooperation with all the parties involved in the value streams. This includes customers and suppliers and all other outsourced services used in the stream of order to delivery. The purpose should be clear to them as well so that all the involved parties can work together to achieve the goal.

4.1.2 Process

The second issue is process and how the organization is going to evaluate each major value stream to ensure each step is valuable, capable, available, adequate, flexible, and that all the steps are tied together by flow, pull, and leveling (Lean Lexicon 2014.) In other words, the whole point is to optimize each step of the process. The pilot projects helped the project team understand what it takes to make changes in the process and what are the most common problems faced in a lean transformation. It is not wise to set the goal to be the ideal state of the process but instead step down from the ideal state to a more feasible future state. Set the target to a level that can actually be achieved with selected changes in the process and in a reasonable time frame. After that target is reached set a new, improved target and keep going.

Management level should think very carefully of what is expected from the improvements in each state. Moving towards the ideal process state is a long journey so the plans should be drafted possibly years ahead. The process starts with an incoming order and ends with a customer delivery and invoice. Each step of that process needs to be taken into consideration to see if improvement can be achieved and at the same time the overall focus should be in the whole value stream and not just its individual parts.

Again, a company should not solely focus on its own processes but help their partners, for example suppliers, to develop their processes as well. This will help companies to achieve a flow through the whole value stream and not just the parts of it that take place in their own factory.

4.1.3 People

The third issue is people. In order to make a lean transformation possible the company needs to make sure that every important process has a responsible person in charge of constantly evaluating the existing value streams from business and lean process point of view. Management needs to ensure that everyone involved with the value stream is actively pushing to making it work as planned and improving it (Lean Lexicon 2014.)

Lean thinking differs from many traditional management styles because it greatly values all the people in an organization. Womack and Jones introduced the idea of managing

from the *Gemba* instead of an executive office space. At the time this seemed like a revolutionary idea and still today it can be hard to swallow to many managers. Also, executives often get fixated in one lean tool and keep using it everywhere and at the same time forgetting the big picture. They also like to think they're involving the people by selecting a handful of people to participate in certain improvement projects. This way the "low hanging fruits" are achieved but the development stops there (Ballé 2014.) This is what has happened so far with the pilot projects and value stream mapping in One Factory. Even when taking into count the factories' own 5S projects and other examples they still only count as baby steps on the way to success. They were a great start but now the whole company needs to move forward and take even bigger steps in becoming a lean enterprise.

Ballé (2014, p.2) highlights three things: visual control, individual skills, and cooperation across functions. Visual control is all about people organizing their workplace to be as visual as possible by themselves. It's about people taking control of their own part of the job, and by doing that many of the underlying problems will become visible to the workers and management. Management's job is to train the people in their organization to accomplish visual control and improve their individual skill set. In figure 25 we can see the relationship between improving visual control and people's individual skills will eventually lead to improvement in the process. This is what Ballé describes as the Lean way.

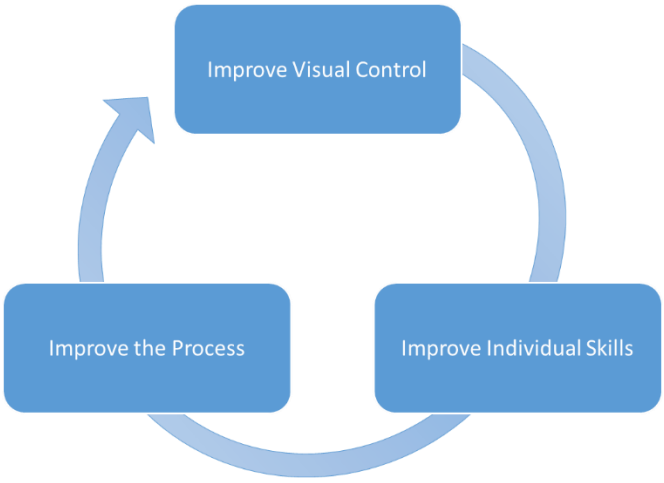


Figure 25. The Lean way (Ballé 2014)

Ballé (2014, p. 3) also describes a set of *Gemba* management skills he refers to as the 7 Steps for Leading Lean with Respect for People, shown in figure 26. They are practices that should be used in daily operations and by actually working and spending time on the *Gemba*. Again, without full commitment, all the efforts, tools and techniques in the world will not achieve permanent results and ongoing success.

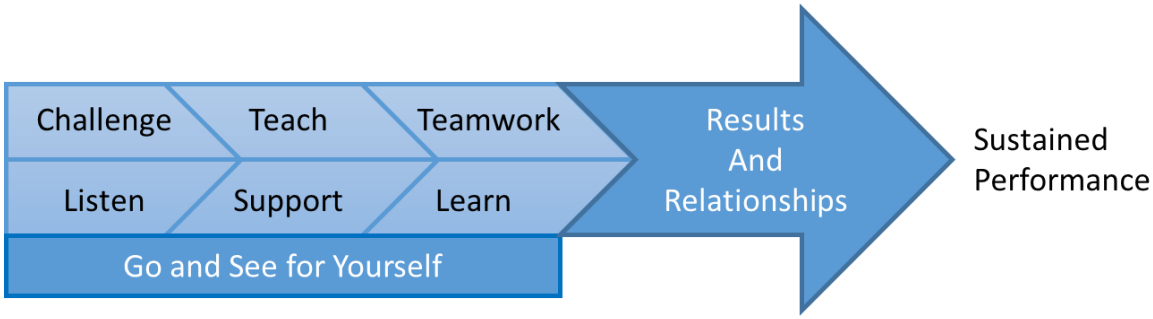


Figure 26. 7 Steps for Leading Lean (Ballé 2014)

1) The first important thing is to Go and See for Yourself, go to *Gemba*. It's the best way of getting people to agree on the problem and its root cause before they start arguing about the best solution. Management needs to base their decision on real events and cases and not just briefings and reports made by other people.
2) *Challenge* is what drives continuous improvement. Demanding more from people whether it be more precise visual control, more exact problem solving and root cause analysis, or better results from the process improvements. Challenge is also about explaining to people how their involvement and the work they do contribute to the big picture defined in the organizational level.
3) *Listen* is about listening to people and letting them explain for themselves what is obstructing their work. When it comes to a certain job the person doing it is the expert so poor management and insufficient flow is wasting that experts' time.
4) *Teaching* is about teaching people improvement and problem-solving skills. Just like in section 3, again one has to recognize that the worker is the expert. Management needs to find a way to communicate with the workers by focusing on solving problems and trying to achieve improvements together.
5) *Support* is about supporting improvement and taking people's ideas and initiatives seriously. With teaching and good communication, the management can avoid having to say no when people come to them with their ideas. It is much easier to say yes when the ideas are small steps for improvement which are also small risk.
6) *Teamwork* is needed when trying to achieve success. Functional boundaries need to be crossed even though at the beginning it's always a struggle. Better quality of team work leads directly to better quality of problem solving and improvement.
7) *Learn* is something that the whole organization will achieve. When the employees receive training they will learn more and when they learn more the management will follow in that learning path. According to Ballé (2014, p. 3) this might be the most profound revelation of lean leadership.

People from One Factory management team have participated in lean trainings by different business consulting companies. One of those companies, S A Partners, presented a pyramid model of the different lean roles within a lean company.

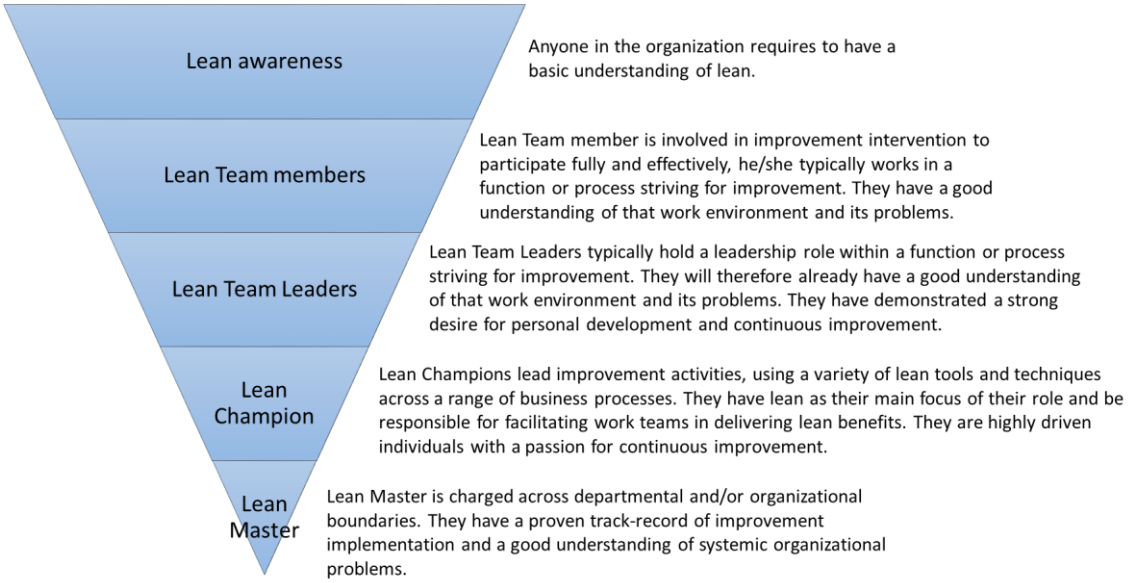


Figure 27. Lean roles (S A Partners 2013)

With the kind of pyramid model like in figure 27 all the people in an organization are involved. It begins with lean awareness and culminates in Lean Masters. At the current state One Factory is on the way to having this kind of pyramid structure but it still needs more awareness and more work to all the people to understand their individual roles in the pyramid.

4.2 Sharing Best Practices

Best practices are specific methods or techniques that have been proven effective and even superior compared to alternative practices. Best practices often become a basis for a new standard in an organization. With One Factory lean implementation sharing best practices is important. Each factory is geographically located very far from each other so sharing must happen in many ways. Lean champions program offers many opportunities for sharing. The selected champions have been trained as a group and have gotten to know each other. Communication within a group that is familiar with each other is always easier.

Knowledge and experiences from the previous pilots should be shared not just by the executive level project manager but among the champions. And when the changes move forward within one location the success stories of other locations should be shared within the whole workforce. The global intranet should be made better use of by sharing stories and best practices in short articles. Lean Initiative database in Metso's Lotus Notes includes a lot of information but only a small group of people know it exists. There's too

little information available for the common worker to get to know what going on with lean in their location versus the other locations.

Sometimes there's also a need to look outside One Factory in search of the best possible solutions. One Factory is still in the very beginning of its lean transformation so there's only so much that can be learned by looking inside the company. There are tons of possibilities, including consulting firms, lean websites, internet forums, books and articles, and lean conferences, where one can learn about other organizations' success stories and their best practices. Benchmarking other companies that are working in the same kind of industry as Metso can easily prove effective.

Creating new One Factory standards should begin with the selected lean champions. By now there should be enough experience among that group that they know what has worked so far and what has not. The champions and One Factory executives should participate in regular workshops where these issues are openly discussed. Executives must trust that with time and gained experience the champions are starting to become experts in their field.

Since One Factory already has ISO 9001 requirements for quality management systems in place they should combine that with lean to create a functioning One Factory quality management system. The two are not in conflict with each other but instead support each other and offer a possibility for a well thought and managed quality system.

Benchmarking between the different factories is an important learning tool which must not be forgotten. The manufactured products are similar enough in every location that there is much to be learned from one location's effective work habits. The familiar saying, go and see for yourself, applies here as well. There's only so much that can be learned from literature or studying previous lean pilots. Sometimes the best way of learning and sharing information is by doing and seeing for oneself.

4.3 Management routines

In order for lean management system in One Factory to work it needs a set of management routines that are in daily use in all the different locations. The first thing to achieve is a common way of visual management. Processes need to be easy to see through with one look. And in order to create a One Factory way of working, all the locations need to contribute in achieving this.

In lean management sharing information is vital. If all the information is only available to upper management how is anyone else supposed to know what is expected of them. Communication should be made as easy as possible, between workers and management, different departments, and different locations there needs to be easy ways of open com-

munication. Lack of communication causes lack of commitment, spreading of misinformation, misunderstandings, and it prevents development. Visual management can often help with achieving open communication in a work environment.

Management also needs to realize that their most important asset isn't the machinery or the expensive ERP system but instead the people working within the organization. To get people to fully commit in the upcoming lean transformation they need to be involved in decision making processes. Again, it's vital to recognize that in many cases the employee is the expert it what they do daily and their voice should be heard and taken seriously. It is important that no matter how small the task is the person doing it should feel they're doing something worthwhile. Money isn't often a good enough motivator when wanting people to give the task their absolutely best effort. Feeling important and making a contribution are more likely to provide long-term satisfaction.

5 CSE ONE FACTORY

Metso Mining and Construction (MAC) is a part of Metso Corporation that offers sustainable technologies and services for the mining and construction industries. MAC's Crushing and Screening business line (CSE) designs and manufactures crushing and screening equipment and delivers them to customers through Metso's own sales organization and external distribution. Manufacturing facilities are located in Tampere (Finland), Mâcon (France), Sorocaba (Brazil), Tianjin (China) and Alwar (India).

In the beginning of year 2012 the management of CSE business line decided to change the way of working in the organization and make all the CSE factories work as one global and integrated team. This new idea was named One Factory Initiative. The goal of One Factory was to review all the best practices from different locations and choose the best among them. Then it would be possible to unify the way CSE factories work and make every action as open and transparent as possible. It would also be possible to use resources and capacities efficiently, globally and safely and to link different development projects together. If different factories work together as a harmonized team it will also be easier to support customers by supplying globally. (One team, one goal – One Factory 2012)

The next step was to initiate a global improvement project and try to standardize the way One Factory locations work and do business. Metso already uses ISO9001 which requires the organization to document their standards but lean could become the driving force in optimizing all those different processes. Maybe lean could provide a solution that would lead to continuous success. The customers are expecting the best quality with the best possible price so in order to answer their needs it is important to be able to do more with less, and instead of working harder work smarter.

5.1 CSE One Factory Lean

Lean has never been globally implemented in MAC or CSE and if local projects have been done there's no record of them in the global intranet. Metso is a large corporation and One Factory initiative concerns factories in different countries and continents. If the goal for One Factory is to unify functions and execute quality improvements, there needs to be clear strategy on how to go forward and it must be applicable to different countries and cultures. There are many great success stories of companies implementing lean in their day to day actions and strategies and this would be the chance to create a new success story for One Factory. In 2013 the management gave the green light to start cautiously going forward with lean. It meant that different locations were able to start their own lean initiatives and some pilot projects were going to be conducted with the guidance of the company headquarters.

One of the biggest challenges would certainly be the fact that these factories are located in different countries and continents and the factory workers have a completely different cultural background. What is clear in lean literature is that for example many American companies have adapted lean very successfully for years now but would people from different countries and cultures be able to accept an ideology based on the success of a Japanese enterprise. And because the way of working is so different in these different locations would it even be possible to successfully implement a standardized method of working? And how can One Factory management be assured that the locations fully intend to implement the whole of lean philosophy and not just make it an exercise of using lean tools and methods to make small improvements? All of these are risks the management and project team need to take into consideration.

The goal of a complete lean transformation was to be able to reduce lead times and eliminate waste by managing the value streams from a whole new lean aspect. One big problem has always been variation in both processes and people. Lean experts promise many solutions to reducing variation as well. Also, when a company has factory locations in several different countries it can be difficult to achieve a common quality. By implementing lean CSE Management wishes that a standard for a unified Metso quality can be created. Production has for many years been highly dependent on forecasting and the accuracy of that forecast is very variable. Production needs to be less depending on that since the accuracy will never reach 100 %. CSE needs to find other ways to plan what is being manufactured.

In order to evaluate the progress and market and competitor performance a clear vision or a "*Northern Star*" needs to be defined. It should state the key performance indicators and what is the target level for each of them. If there isn't a clear understanding of the current conditions, it is vital to start with evaluating that. To achieve continuous improvement there needs to be a target state but after that becomes a new target and after that again a new target. That was the goal when defining the approach and goals for One Factory Lean.

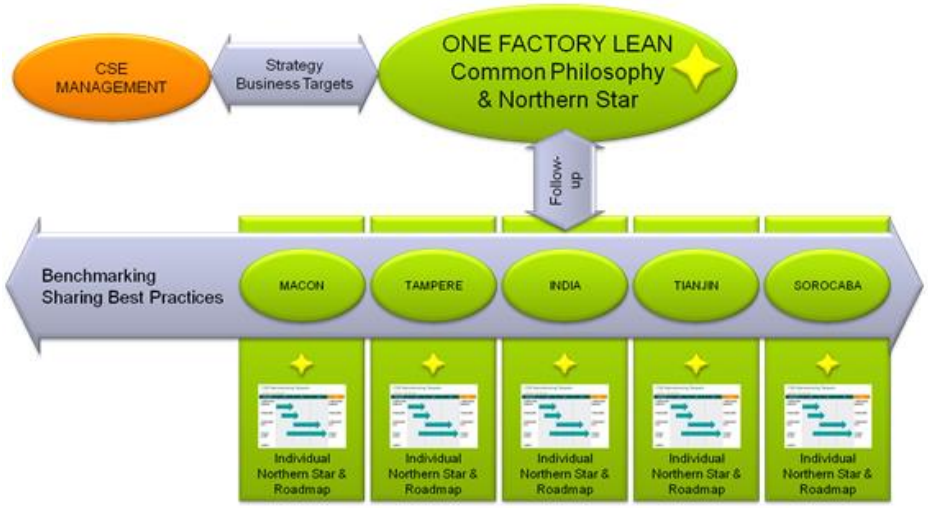


Figure 20. CSE One Factory Lean approach

In figure 20 the approach for One Factory Lean is defined. The transformation is managed from the upper level but each location has the chance to influence what will be done and in what order. Each of the One Factory locations needs to be able to go ahead with lean implementation at their own pace. Some locations have been producing the same equipment for decades and some have been founded very recently. That is why different locations need to set their own goals and "Northern stars" and corporate management just has to monitor the progress from above. The goal is that in the future each location studies the Toolbox and Management System, seeks more training and then makes decisions about where they want to begin and where they want to go. Lean training is necessary for the selected key people in different One Factory locations because a simple Toolbox and Management System are not sufficient when the goal is to fully understand lean.

Lean Toolbox should be located in an easy access area in Lotus Notes Lean database, where any Metso employee is able to access it when necessary. It should also be as self-explanatory as possible so that a person isn't required extensive lean training to understand the basic principles.

5.2 Gaining competitive advantage

Taiichi Ohno, the founder of Toyota Production System said: "*All we are doing is looking at the time line, from the moment customer gives us an order when we collect the cash."* (Ohno 1988). Lean lead to improvements in the cash flow. That is the thought with which this project started and that timeline is pictured below.

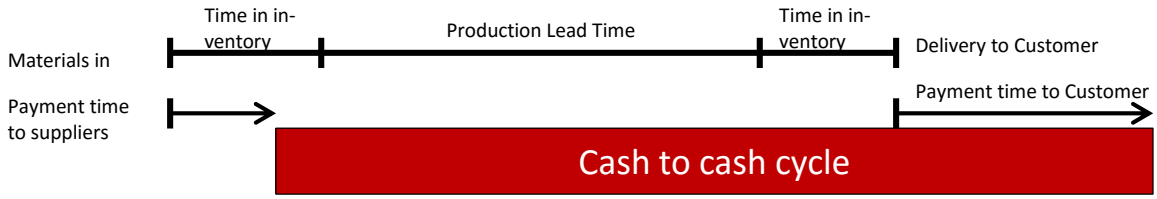


Figure 21. Cash to cash cycle (Capacent 2013)

Metso can't act like a bank that gives customers unlimited payment times while at the same time paying their own suppliers in a shorter time. At the same time all that money is tied up in materials, production, and different inventories. Cash to cash cycle in figure 21 represents this issue. The shorter the cycle the quicker the profit can be achieved.

First the different business challenges were defined. There are Time challenges, Financial challenges and Quality challenges described in figure 22. Time challenge means too long lead times in a process where faster service is required, Financial challenge is cost or price reduction pressure and Quality challenge consist of customer claims and poor quality with high cost. One of the important questions was also if the biggest challenge is sales forecasting inaccuracy or lead time. All of these are issues that were dealt with on a daily basis and prior improvement projects had not found a lasting solution for them. There wasn't a clear vision of which one of these was the biggest challenge either. The hope was that with a lean approach and the pilot projects it would be possible to identify the root causes for these and find solutions and ways to improve. If the project team were able to execute the pilots is a manner that would bring wanted results they would serve as undeniable proof of the usefulness of the lean concept. After that it would be easier to get the executive level to fully commit in a lean transformation and the global transformation process could begin.

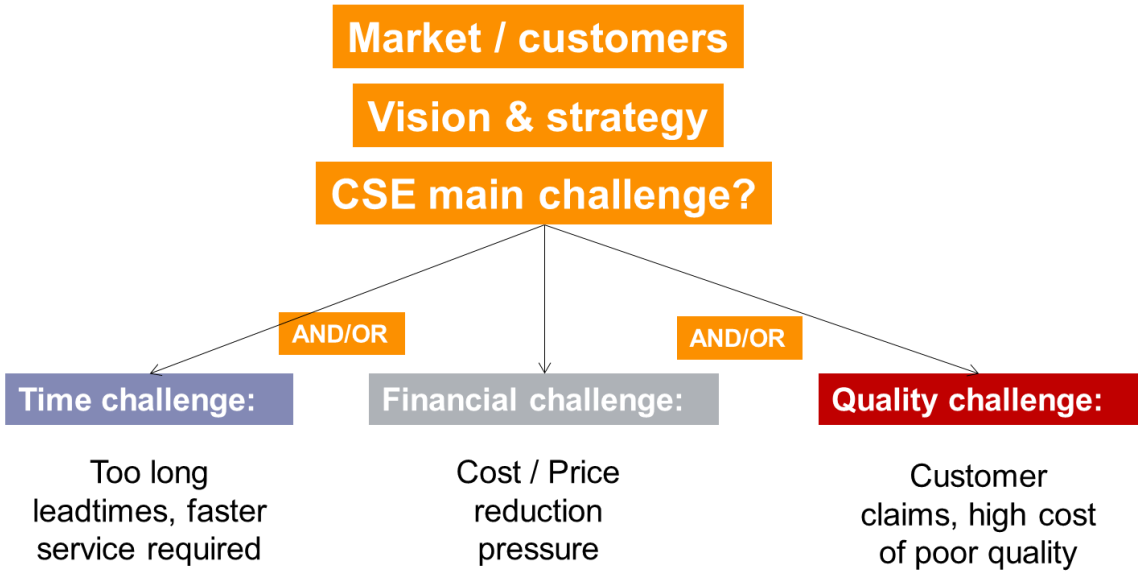


Figure 22. Lean business case: What is our business challenge?

6 CSE ONE FACTORY LEAN TOOLBOX

One of the main goals for this thesis was to create a global One Factory Lean Toolbox for people to use. Metso has a global database in Lotus Notes and CSE One Factory Lean Toolbox will be introduced as a part of the new Lean database. That way all the tools and techniques containing the theory behind them and ready to use templates are available for everyone everywhere. When Lotus Notes will be replaced by another system in a couple of years the Toolbox and database will be transferred to the new system.

As explained before, the first step in creating a Lean Toolbox for One Factory was to study the literature. The Toolbox should only include tools and methods that are suitable for all One Factory locations and personnel. At this first stage of lean implementation the chosen tools should also be simple enough for beginners to use and understand. The study was executed mostly by getting to know lean literature and using previous knowledge gained from writing a bachelor's thesis and starting with the reference materials provided by the project manager. In December 2013, Metso organized a two-day lean production training for its personnel where the basics of lean were introduced in a practical way and it was decided by the project team that attending the training would be useful for this thesis and the planned pilot projects. The contents of the course broadened the view of implementing lean in a Nordic production company and gave some good ideas on how to continue with the pilot projects.

6.1 Selected tools and methods for CSE One Factory

There are several lean tools and methods introduced in literature, in the internet and in different lean trainings. Selecting the right ones to begin with was not easy. It was vital to choose those that are simple to understand and use in Metso's work environment and for which ready templates could be made in order to make things as easy as possible for the user. The user might only have a very narrow understanding of lean and its possibilities so the toolbox shouldn't overwhelm the user with too much information. The idea should be that the user has had some basic lean training and knows why lean is being implemented in the global factory network. They should understand the global and local overall targets and see the possibility for improvement with lean.

It is also crucial to understand what the main business in One Factory is and where the real money comes from. What are the main areas that need improvement? In Metso's One Factory locations the designed and manufactured products are crushing and screening equipment. When thinking of manufacturing, these machines are large and a big number

of the parts used in construction are supplied by other companies. Usually only the larger main components are manufactured by Metso and the manufacturing really only includes assembly. Taking this into consideration it soon becomes clear that lean tools which are focused on fine adjustments or tunings of parts manufacturing are not at all suitable.

Since One Factory Lean is at its early stage many of the suitable tools are used for analysis of what is important and what should be improved. They are used for evaluating the current situation first on a bigger scale before focusing the attention to the little details. Many of the tools require actually going to the manufacturing site and analyzing the situation with one's own eyes. What people in One Factory need to learn is to really see the existing problems and by seeing try to understand the different causes. And again, by understanding the causes try to seek solutions together by using lean tools instead of trying to place blame.

Defining value and value streams seems to be the key in lean philosophy. It was also a key aspect in One Factory's lean project. That is why many of the selected tools are focused on understanding where value comes from and how it can be added to the order to delivery process.

The following tools and methods met the conditions listed above. Some of them were tested during the pilot projects and some of them were chosen because they were seen as tools which can be easily implemented in One Factory.

Kaizen workshop

Liker's (2004) vision of a *Kaizen* workshop is based on creating value stream maps and developing the process using them. The basics of value stream maps are presented next and appendix 1 presents the basic frame of the workshop. There are five points to do before the workshop to reassure effective time usage:

1) Define the scope clearly enough
2) Process owner needs to set measurable objectives for the team
3) A preliminary current state value stream map needs to be created
4) Collect all relevant documents
5) Post the preliminary current state map in the team's meeting room

When initiating the pilot projects this 5-point list was not included in the materials presented to the project management team. However, this is basically what was done during the first stages of the project so it seems reasonable to include such a list to the toolbox so that any following projects can have a similar starting point and the results can then be compared.

7 wastes and going to Gemba

Appendix 2 is a template for an exercise called *waste walk* where the point is to take a look around and observe the different types of waste happening in that environment and make some suggestions on how to fix those issues. Going to Gemba or going to the place where the real action happens is an important way of making accurate observations of the process. It usually makes it easier to locate the biggest problems when seeing the process in action. Sitting in an office executing a workshop might not often prove as effective as a walk around the factory site.

In the pilot projects this type of thinking wasn't necessarily used enough. It was clear that management and manufacturing staff often had very different opinions on what the biggest problems were. Going to Gemba and discussing the current situation together with the people working there should help everyone to better understand each other's point of view. That would decrease the risk of manufacturing staff feeling that their opinion is not heard or understood and boost the feeling of working together in order to achieve a lean factory.

5S methodology

When this thesis was initiated in the fall of 2013 the first lean implementations took place in different One Factory locations. In Tampere factory the first step was utilizing 5S methodology in production. This was a completely separate project from this thesis and the template presented in appendix 3 has not been used in this Tampere project. In many cases the 5S is used simply as a clean-up project where the goal is to make the work environment look tidy. That is what happened in Tampere when the separate 5S project reached the main office building. It was labeled as a clean-up project where everybody's task was to clear their desks and workstations and afterwards a check-up round was conducted. There wasn't enough emphasis on how to make this a permanent routine in the office so that the 5S becomes a part of everyone's daily work.

The important thing when designing this template was to make the user understand the full potential of the 5S and how it can actually make production or any other kind of work more efficient and safe. The template must also be easily applicable in different work environments such as shop floor and office.

Value stream map

Creating value is crucial when a business wants to be successful. In order to create value one needs to understand where it comes from. Mapping the process and the thus the value stream makes this simpler. Managing the value stream was one of the main goals for Metso's lean project so this was naturally the first tool selected to be included.

The first pilot project actually began by creating a template for the Value stream map. There are naturally many different models available and in this case it was decided that Microsoft PowerPoint would be used as a tool. With PowerPoint is was easy to draw all the different symbols that were going to be used in this map and then it would also be possible to compile a whole PowerPoint presentation around the Value stream map in order to explain the background and the project plan in further detail. PowerPoint is also a program that is installed in all Metso MAC CSE computers so when the Value stream map is being forwarded via email to many people PowerPoint is a safe choice. An empty template of the Value stream map is illustrated in appendix 4.

It uses stock coverage weeks and days instead of monetary values to describe the size of inventories. That makes it easier to understand where too big stock is located and what is causing it. The map should also give an understanding of where time is wasted and what functions should first be improved. However, since lean is a continuous improvement process the user of this template shouldn't expect to have everything ready and sorted out just by using the tool once.

Value stream map for suppliers

Mapping the value stream all the way to the suppliers is crucial in order to evaluate the whole process. Especially in the first pilot it revealed some very interesting information and highlighted the differences between the suppliers. Appendix 5 is a ready-made template that can be used in all One Factory locations to map the supplier value stream. It was drafted during the two pilots. Since there are often tens if not hundreds of suppliers for components required in CSE products it's important to first find the most critical ones based on inventory value and planned delivery time and start with them. The template requires the user to calculate a weighted average (based on inventory value) of the supplier components' planned delivery times. It also needs the inventory values for supplier stock and stock at Metso factory. The inventory value is shown both as EUR amount and stock coverage per days. Stock coverage measured in days gives a better understanding of possible overstocking.

Future state Value stream map

Also an important part of Value stream mapping is defining the target or future state value stream map. It should be based on the same template as the original map (appendix 4) and it should define the targeted state of all functions in the map. A target state was defined for both pilot projects by visualizing it through a future state value stream map. Visualizing the goal is important and should always be included in any lean projects. That is why it needs to be included in the toolbox.

A3 – project management tool

Any lean project needs to be managed and A3 proved to be very efficient in both pilots. In addition to the value stream maps it was one of the essential tools to be included in the toolbox.

Appendix 6 is an A3 template that was used in both pilot projects. The main goal was to simplify all the smaller improvement projects so that the project team could manage them in an easy and efficient way. Just one look at the template was enough to define the starting point, the current status and the next steps of the project. When the lean transformation in One Factory moved forward the template was developed further in a lean champion workshop but appendix 6 was the original template used in One Factory Lean.

5 x why

The 5 x why method is an easy method to use if the user understands the goal of finding the root cause behind a problem. Finding the root cause is a lean thing to do and this is why this tool was added to the toolbox. It is also very easy to understand and use when working in a group which doesn't have that much experience with lean. Appendix 7 is a simple template for defining the root cause behind the problem and its symptoms.

Kanban

Appendix 8 includes an *eKanban* process description, a traditional version of a *Kanban* card that can be used to control the flow of materials, and a very simplified version of a *Kanban* board. An *eKanban* process was already implemented in the first pilot when reorder points were re-programmed into the ERP systems. A traditional form of a *Kanban* card might not be as efficient as it used to be since almost all production systems are now managed electronically. Still, it is good to know the basics of *Kanban*. A *Kanban* board can be as simple or as complicated as necessary. However, it should be remembered that it is a visual tool and one look should be enough to determine its purpose. A simple version can be just a whiteboard with post-it notes telling which task are to be done, which are in the process of doing, and which are already done.

When the pilot projects were initiated managing inventory (whether it be parts inventory, work in progress, or finished goods inventory) was proven to be very difficult. That is why a well-functioning *Kanban* system should absolutely be implemented into Metso's ERP system and why this tool is included in the toolbox.

Bottleneck analysis

When analyzing bottlenecks, one must take into consideration the different factors related to them. Often the human factors are left with no attention and the end result is not as good as it could be. A process capacity chart like in figure 9 on page 28 can be used to

define the capacity of different stages of the process. In the first pilot some of the bottlenecks in production were identified from the value stream map. Even before the pilot the manufacturing manager had decided to re-organize the production work stations for engine and final assembly. This then became a goal also in the pilot to even out the workload in the different stations, establish a decent flow, and get rid of any bottlenecks. This was to be done together with procurement to make sure all the needed materials would be at the right place at the right time.

Because no specific template was used during the pilots the toolbox will include the theory of making a bottleneck analysis. The theory will include figure 9 so a similar chart can be used in One Factory locations.

Poka-yoke

Poka-yoke is another method which wasn't used as such during the pilots but is included in the toolbox. Quality control was an important factor in the pilots since defects can cause disruption in the process, they require re-work for the machine, and they can result in claims from the customer. The work performed in different One Factory locations still varies quite a lot so it was decided that it would be better to just include the theory in the toolbox and let the different locations develop their own systems of error-proofing.

Visual control

Visual control is again one of the main themes in lean. To be able to deduce the function of some part of the process by simply looking at it makes things easier to manage. Some forms of visual control have already been used in One Factory locations for a long time. Most of them are related to different aspects of safety, such as marking the visitor paths with a certain color or securing a specific work area with another color. However, visual aids can help with efficiency as well as safety. In many work stations there could be visual aids telling you how to perform the tasks on that particular work station. Also when working with large objects and power tools the risk for accidents is high. Visual aids will help decrease those risks and remind people efficiently to remember all the important safety aspects.

Appendix 8 includes a *Kanban* board which is another visual tool for evaluating the process status. For maintaining 5S more visual aids could be used to assist people finding the right locations for different items.

6.2 Lean for the office in CSE One Factory

When this thesis was initiated the main focus was in production. Later on some other departments have joined in on the pilots and tried to transform their operations according

to lean philosophy. The next logical step would be to bring lean closer to the office environment. In January 2015 a 5S cleaning project was executed in Tampere headquarters but that is just a very small step when trying to establish a lean culture.

With all the tools and methods presented in the appendices different departments that work in an office environment can start evaluating the work they do and create standards for all work performed. In the first pilot Tampere order office was able to take several days off their normal lead time by improving their processes and creating new standards. Lean manufacturing doesn't help gaining competitive advantage if the office part of the company lacks in lean philosophy.

6.3 Excluded tools and methods

There was a couple tools and methods that were studied but was left out of the toolbox. One of those methods was SMED. Most of the smaller parts which require actual machining are supplied by subcontractors. SMED includes a lot of fine adjustments and with One Factory's end products the focus should be on the bigger picture at least at the start of the lean transformation. The first goal was to pick out the "low hanging fruits" and work on the bigger problems, and saving some seconds in adjustment time is not one of those big problems.

Another method that was left out was the safety and ergonomics aspect. Throughout Metso the safety issues are already well looked after and it would be wasted work to include those in the lean toolbox since there is already a clear health and safety strategy in place. For example, in One Factory there is a tool available in the intranet page where anyone can report a risk or hazard they've observed. In Tampere factory any accidents taking place are carefully investigated and reported to the entire personnel. There is a huge board near the Tampere factory main gate telling how many days without injuries have gone by. Safety is obviously already a huge part of the daily operations so in that sense the lean transformation has been going on for a while now. In Tampere factory also the occupational health experts of their own medical center are available to execute evaluations of different work stations to determine if ergonomics needs to be improved.

7 LEAN PILOT PROJECTS

Shortly before starting this thesis One Factory management team made a decision to go cautiously forward with lean. In the beginning it wasn't made public in any way but it gave an excellent topic for this thesis and a green light to a couple of pilot projects. Depending on the successfulness of those projects the management team would make further decisions concerning lean approach in the global factory network. During this thesis two pilots were initiated in two different locations and more would follow later in the transformation process.

At the same time Tampere factory was starting their own 5S project which included training for a selected group of people from different factory hierarchy levels. The training was a very practical approach to lean and 5S and the trainees would then become lean coordinators in the factory. This thesis was executed at a perfect time regarding the similar goals of these projects and there was some collaboration and good discussion with the 5S project members and thesis worker about the lean pilot projects related to this thesis. Both parties were interested in the others' work.

However, the projects differ quite significantly since the 5S project was executed in a bottom-up manner. It began at the shop floor and later made its way into the office. The theoretical lean background wasn't very highly advertised, perhaps because the plant manager did not want to scare workers into thinking they will need excessive training in order to understand the changes. One Factory Lean began from a different approach. It initiated in upper management and made its way down to shop floor. Also the perspective of this project was global instead of local. Every decision and improvement should be possible to replicate in any of the other One Factory locations. But since the 5S project was already ongoing in Tampere at the beginning of the first pilot it was perhaps accepted easier compared to the second pilot location. Lean was becoming more and more familiar at least to the shop floor personnel and the routines began to stick.

7.1 Commitment to Lean

The beginning of this lean implementation was executed very cautiously because there was only an initial commitment from the management team. The selected pilot projects, if successful, would provide the necessary security to go fully forward with lean. In March 2014 the business line and One Factory management team attended a lean kick off workshop. The final approval and full commitment came after that and the pilot projects had proven early improvement in the product lines profitability.

Now the transformation towards becoming a lean enterprise was well on its way. One Factory lean management initiated a search for applicants willing to become lean champions of the different One Factory locations. The goal was that the future projects would be lead locally by them. What is required in the future from these champions is spreading the lean culture throughout the different organizational levels and getting the whole personnel involved and committed in creating a lean enterprise.

Figure 23 presents the pilot project manager's view on how One Factory should evolve from its current state towards the target status. This view is based on the efficiency matrix of Modig et al. (2013, p. 100). The two first pilots were meant to help prove that this type of transformation would be possible.

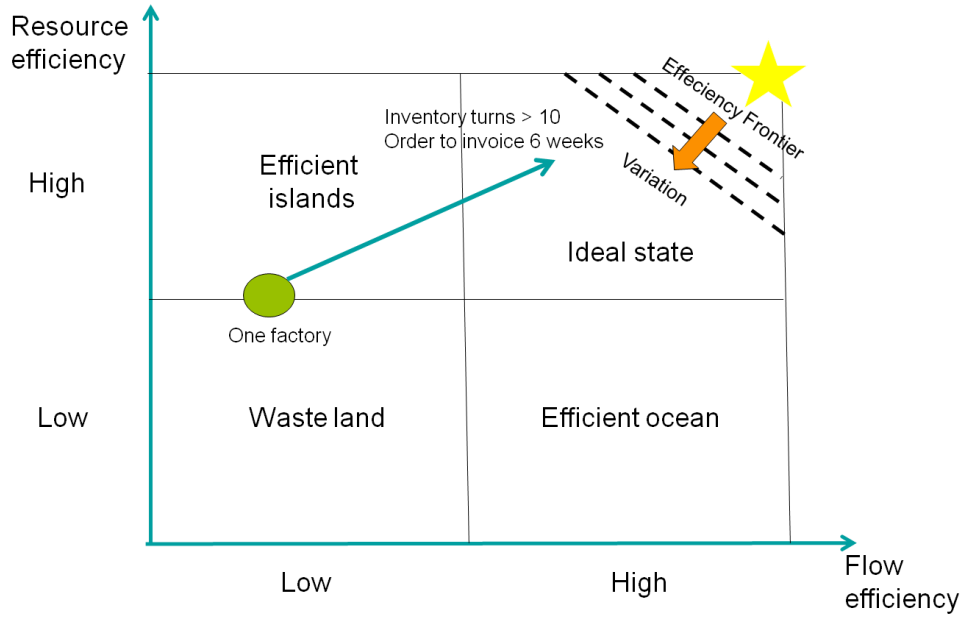


Figure 23. One Factory lean target state (adapting the efficiency matrix of Modig et al.)

After the first two pilots the transformation was meant to start moving forward globally. More pilots were to be initiated in different locations and the most critical product groups would be selected for these pilots. Some of the factories had their own lean initiatives so benchmarking those would most likely prove interesting and help lean project management create companywide standards and learn from what has not been found successful.

7.2 Lean basic principles in One Factory

The project manager had attended lean training for some time before the pilots were initiated. During that training some of the principles and goals were already determined and a plan for the future of the lean transformation was drafted. That plan can be seen in table 2. As for the schedule a 5-year plan of Womack and Jones (2003, p. 270) was used as an example.

Time	Months 0-6	Months 7-24	Years 3 and 4	End of year 5
Phase	Getting started	Create a new organization	Install supporting business systems	Complete the transformation
Actions	• Find a change agent • Get lean knowledge • Find a lever • Map value streams • Start *kaikaku*s • Expand your scope	• Reorganize by product family • Create lean organization • Device a policy for excess people • Device a growth strategy • Install perfection mindset • Remove anchor draggers	• Introduce lean accounting • Relate pay to firm performance • Implement tranparency • Initiate policy deployment • Lean learning • FInd right tools	• Apply these steps to suppliers/customers • Develop global strategy • Transformation from top-down to bottom-up development

Table 2. Time frame for the Lean Leap (Womack and Jones 2003)

The first six months is used by getting started with lean, the next time period up to two years is used creating a new organization, years three and four should be used installing supporting business systems to be able to maintain lean and from year five onwards the transformation should be complete.

The way of selecting improvement projects in One Factory was also clearly defined from the beginning:

1. Select business case for Lean
    - define the team, approve the project (pilot), kick-off the project
2. High level value stream mapping to define the main challenge
    - suppliers, factory, customers
3. Value stream mapping
    - identification of block for the flow and waste
4. KPI selection & target setting to meet business case targets
5. Define future state value stream map
6. Plan improvements: flow efficiency & waste free
7. Plans deployment & problem solving

The progress of these projects was to be followed-up in bi-weekly meetings with the team. The main targets for each project was to achieve continuous flow, one-piece flow, defect free production and product and lower the cost significantly.

Another principle that was relied on was the basic laws of process functionality according to Modig et al. (2013, p. 31-43). These laws shown in table 3 explain what causes the rise in throughput times and how easy it is to end up in a situation of efficiency paradox.

Little's law	Bottleneck's law	Law of variation
• The higher number of units in process and the longer cycle time, the longer throughput time • Throughput time = units in process (WIP) * cycle time	• Bottlenecks and constrains increase the throughput time • If the bottleneck is removed, then other parts of the system will become bottlenecks	• The wider the variation in the process and the closer 100% resource utilization, the longer the throughput time

Table 3. Basic laws of process functionality (Modig et al. 2013)

In figure 24 the relationship between variation, resource efficiency and throughput time is explained. That is why it is important not to focus too much on resource efficiency because in situations of high variety the throughput time will suffer significantly.

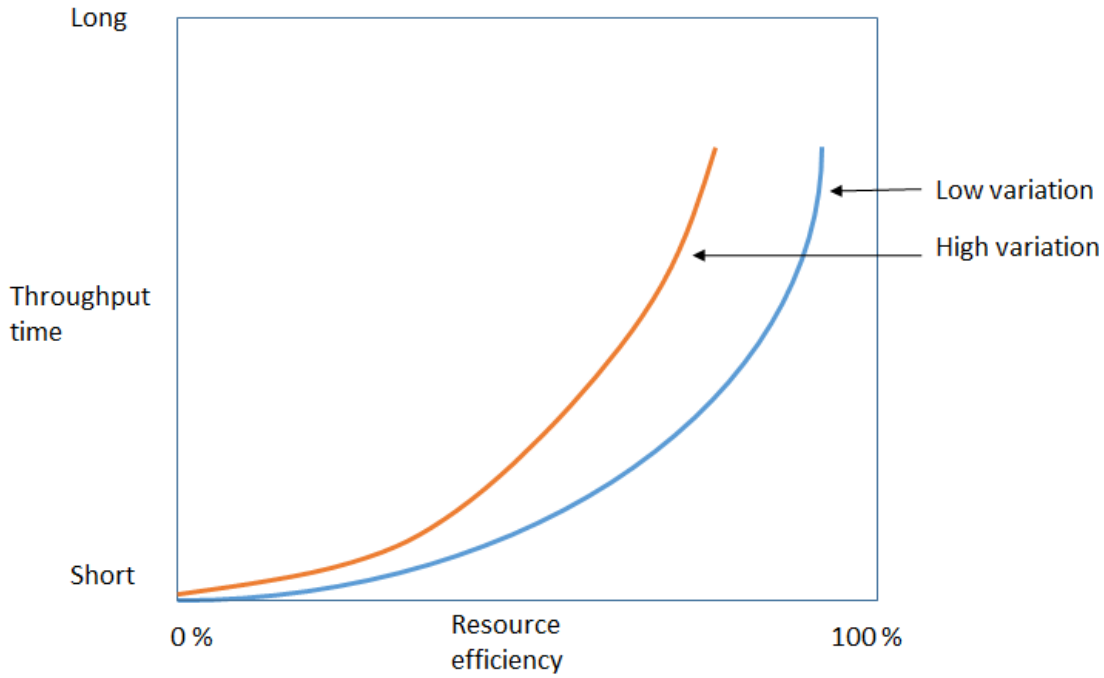


Figure 24. The connection between variation, resource efficiency and throughput time (Modig et al. 2013)

A list of key figures to follow in the pilot projects was drafted by the project management team. The table shown in appendix 17. First the actual numbers of year 2013 were listed, then a target for 2014 was set. From the beginning of 2014 the numbers were followed

monthly and if it seemed that the original target was set too low it was later revised. The last five rows on the table are the most important leading indicators from the company's point of view. The accuracy of orders received, number of supplier quality claims, number of design change requests, supplier delivery accuracy and order acknowledgment lead time. The color coding is green for on target or better, yellow is for max. 20 % below target and red is critical, more than 20 % below target.

7.3 Lean pilot for product group X as proof of concept

In order to assure CSE Management of the benefits and effectiveness of Lean it was necessary to initiate a pilot project as proof of concept. Pekka Ahokas from Metso Minerals, Inc. headquarters was appointed as the project manager and this thesis would serve as a necessary project resource. The first Lean pilot as proof of concept was initiated with product group X which is manufactured in Tampere. Product group X includes six different products which vary is dimensions and working capacity. Before diving further into the world of Lean tools and methods there was a clear need to execute a simple Lean pilot for learning purposes.

The pilot was managed by a small team which was led by the project manager and included the thesis worker. The project manager then gathered a larger group of people who were responsible for different parts of the order-delivery process of product group X. This group got together in bi-weekly steering sessions to first view and evaluate the current state and then later to check the progress in the improvement projects. The people in the steering group agreed on the actions to be taken in the near future and in the time between the steering sessions were responsible for making the agreed actions happen in their designated part of the process. The management team did not take part in daily management of the product group's value stream but the steering group members were responsible for reporting the progress or any faced challenges to the whole group.

Value stream map was chosen to be the starting point because it is a fairly simple lean method for beginners to understand and use and it was defined earlier in the basic way of selecting improvement projects in One Factory. The picture format made it easy to describe the current situation and it was easily limited to a defined entity which in this case is the product group.

It was believed that a Value stream map could help the project team to discover the biggest problems and issues in this order-to-delivery process. With a target state value stream map, it would also be quite simple to demonstrate the targeted situation in picture format. When dealing with different departments and different managers and supervisors in this project it was believed that a Value stream map would be equally understandable for everyone.

7.3.1 Background

Product line X has been struggling with low profitability and quality problems for some time and that is why it was a logical choice for the first pilot project. It was also an easy choice for the first pilot because the manufacturing unit is situated in Tampere. It was suspected in advance that it would be easier to go forward with the first pilot if the project's participants could communicate mostly face-to-face which proved to be an accurate estimation.

Some ideas of improvement had already been discussed especially in manufacturing and now with the help of a pilot project even bigger progress in the whole process would hopefully be achievable. It was just a question of making sure that the existing ideas would be consistent with a lean approach.

It was already clear that there were difficulties in forecasting and it caused losses because wrong types of machines were manufactured and there wasn't a demand for them. Manufacturing relied very strongly on the forecast and the forecasts weren't reliable and changes in different markets couldn't be seen beforehand in them. Product management had decided to manufacture machines based on forecasts because it was believed that customers purchasing this type of product need to be able to get it almost right out of the shelf. In reality the machines in storage rarely met the customer's specification and often needed to be altered in one or more ways. This caused disturbance to the assembly line making all other machines late. The whole process needed to be changed so that machines would be manufactured mainly based on an actual need and at the right time. And the new process needed to be more flexible so that a continuous flow could be achieved.

7.3.2 Value stream map

The next step was to gather all the necessary data for a value stream map. It was decided that since it would take much longer than is reasonable to gather absolutely accurate financial data on all necessary areas that in this project roughly accurate data would be sufficient. Even roughly right data would reveal all the biggest problems in the process. Two products were excluded from the project because one is a ramp down product and the other is sold very rarely and its manufacturing is outsourced.

The first thing to do was to find out our inventory value for product group X. Metso is using SAP so collecting roughly right data from there is quite simple. Total inventory value was then divided into finished goods inventory (FGI), raw material inventory (RM) and work in process (WIP). These products were manufactured in line assembly. There were four engine module stations, two frame preparation stations and four final assembly stations. After that came testing, then packaging and then the machine was transferred to another company where finishing touches are added. Manufacturing couldn't give an accurate estimate on how WIP was divided between these stages so it was decided that in

the VSM there would only be five stages of manufacturing; Engine assembly, final assembly, testing, packaging and the outsourced finishing work. That made four places for WIP in between, WIP1-WIP4. A rough estimate was that WIP1, WIP2 and WIP3 were about the same size and made up about 20% of the total. WIP4, however, is much larger and made up for about 80% of the total. FGI also needed to be divided because there were a couple of different types of FGI storage. There was one stock at the company where finishing work was done and then there were other stocks around the world at Metso's local sales units.

To make the VSM easier to understand it was decided that instead of monetary value the map would state inventory values in weeks, in other words how many weeks' worth of inventory exists. The goal was to make the map easier to understand because simple amounts of money are often hard to make sense of. Since the monetary values of different inventories were known as well as the average cost of a single product the how many weeks' worth of inventory can be calculated by dividing inventory value first with the average product cost and then with the actual weekly output,

$$Inventory\ value: \begin{matrix} How\ many\ weeks' \\ worth\ of\ inventory \end{matrix} = \frac{\frac{inventory\ value}{average\ product\ cost}}{actual\ weekly\ product\ output}. \qquad [3]$$

This method also makes the results comparable with Value stream maps of other locations where the monetary values and currencies can differ quite a lot. Comparisons to the total lead time, supplier lead time and production lead time are also possible.

The next thing was to investigate the cycle times in different stages of the process. After a study of the weekly outputs of the whole process and the different stages it became clear that the weekly output varies quite a lot and there wasn't a decent flow in the process. Appendix 9 shows the variety in weekly output per process stage and total weekly output which were actual customer deliveries. There was so much fluctuation that flow efficiency was at a very low level and bottlenecks obviously occurred in the critical stages of the process. Appendix 10 shows the current state value stream map that was drafted for product group X.

7.3.3 Supplier Value stream map

A big part of establishing a flow in the process is to improve co-operation with suppliers. Since the order-to-delivery map is not the best way to describe supplier value streams another separate map on suppliers was created. Data was gathered from the system to determine what the most critical parts among the tens or even hundreds of parts used in manufacturing were. A weighted average of the parts' suppliers inventory value at

Metso's storage and the average planned delivery time was then calculated and based on those numbers the most critical suppliers were chosen. Eleven suppliers stood out and then a value stream map was constructed with them. It shows the inventory the supplier reserves for Metso at their own storage, average PDT, inventory at Metso's storage and the monetary value of it. Appendix 11 shows the supplier value stream map that was drafted for product group X.

7.3.4 Selecting improvement projects

When studying the Value stream map more thoroughly it was soon discovered that there were several possibilities for improvement in the whole order-delivery process. The VSM that was used really pointed out that there were wasted time and resources in every step of the map. The key people who assisted in getting the right numbers to the map were made a part of this project. Some of them were at the same time participating in the 5S project so they knew the purpose of a Value stream map and the basics of lean.

Appendix 12 shows the biggest problems which were noticed in the map. The first thing was low accuracy of sales forecast. The production was highly dependent on the forecast and when it failed there were machines produced without any demand. Since achieving improvements in the process flow and lead times is a long process and it may take time before it is possible to manufacture machines only for an actual demand the first project was to find ways to improve the forecast accuracy. This isn't actually a very lean kind of action to take but it was a target set by an executive level so it had to be made a part of this pilot project.

The second thing was order acknowledgement lead time which is the time it takes for a customer to get an order confirmation through order office. The average order office lead time for a product from group X was 10,6 days which seems excessive since the products are supposed to be standard-made machines with very little customization. Communication with production shouldn't also be too difficult since both production and order office are located at the same lot and share production planning personnel.

The next obvious things were supplier payment times which then lead to customer payment times. In this case the average payment time for suppliers was shorter than the payment time for customers. This causes the factory to operate as a bank and losing money when instead the situation should be reverse. The customers should pay the factory in a shorter time period than the factory pays the suppliers. This was to be achieved by negotiating with both suppliers and customers when renewing contracts.

When looking at raw materials and supplier manufactured parts there was a big problem in both lead times and inventory values. They were naturally dependent on each other. As long as the lead times remained incredibly high the inventory levels needed to also be high in order to secure the necessary parts and materials for production. Procurement team had been under pressure to ensure the necessary inventory levels remained so with

some materials they have started to purchase larger amounts to make sure the materials never run out. This resulted in a situation where there were some materials in the inventory that weren't even needed in production anymore. That, of course, is categorized as waste. The supplier value stream map revealed the most problematic suppliers and materials so it was clear where procurement should start mending the situation. Appendix 13 shows a statistic of the material lead time per material vs. demand (width) and from that it is visible that even some of the very high demand parts have a significantly high lead time.

Production lead time was an obvious improvement project when trying to implement lean in any company. It was also a good place to start since the manufacturing manager already had plans on how to modify the work stations and thus improve lead times. One important point was to start engine assembly at an earlier stage to get better compatibility with the start of the final assembly. There was one problem which proved not so easily solved. There had been issues with product appearance and quality of paint job and for that reason the finishing and final packaging was outsourced to another company located a 150 kilometers from Tampere factory. This caused additional need for transport, it cost money and time was lost. Since it was believed that it would take time to get the quality to a level which didn't require any additional finishing the team decided to take a look at possibilities of executing the finishing procedures in Tampere factory. This would also require some training for the assembly line workers so that fewer damages would occur to the painted surfaces during assembly. When modifying the production lead times and layout the work in progress (WIP) inventory needed to also be reduced. The largest WIP was between the packaging at factory and the outsourced operation. If the outsourced operation could be eliminated the WIP could also be investigated further and probably reduced.

The last big thing was reducing the finished goods inventory (FGI). There were actually three separate FGI's, one in the factory, one at the outsourced operations company, and one with the distributors or Metso Sales and Service Offices (SSO) around the world. Again the problem was that these machines were often not manufactured to meet an actual end customer need but the forecasts from distributors and SSO's told the factory which machines they wanted to purchase to their stock. Many times the forecasts were completely inaccurate and some machines were left in inventory for a year or even two. That resulted in a high value of FGI spread around the world. Machines left in inventory for a long time also become a warranty problem when the end customer wants a full warranty plan for a machine that has been waiting in storage or a distributor's yard for a long time. Also the machines in factory FGI often had to be modified when an actual end customer made an order because the specifications didn't quite meet the machine that was ready at the time.

7.3.5 Defining targeted situation

The targeted situation was initially set by the project manager. The first list of targets is shown in appendix 12:

- Order intake forecast accuracy to 80 % level
- Order acknowledgement lead time reduction by 75 %
- Supplier payment time from 43 to 46 days
- NWC weighted material lead time reduction by 30 %
- Raw materials inventory reduction by 50 %
- Production lead time reduction by 50%
- WIP reduction by 30%
- Outsourced operation elimination
- FGI reduction by 50 %
- Customer payment time from 82 to 60 days

Each of these was to become its own mini-project which had a project responsible who reported to the project manager and the rest of the project team. An A3 project management template (appendix 6) was created for this purpose and each project was defined in its own A3. This thesis worked as a project resource and all the data for these projects and defining the projects in the A3 template was done by that resource. In appendix 14 is an illustration of all the different A3's, the first improvement project is shown on top.

7.3.6 Revised Value stream map for product group X

When the targeted state was defined a new value stream map was revised. Appendix 15 paints a picture of the targeted state. It shows significant changes in the order process, supply process, manufacturing process and delivery process. Also in the beginning of 2014 the project team was interested in seeing where they are at the moment. So another value stream map was drawn in order to show them the current state after Q1 in 2014. At that time some improvements had been accomplished but a lot of changes still remained to be executed. That map is pictured in appendix 16. Also an important part of the bi-weekly steering sessions was looking at a chart of key figures for this product group. At the beginning those figures were collected from the previous year, targets were set for the next year and every month those figures were collected in order to see some progress. The fields were color coded so that it would be easy to see with just one look where the project is going well and where more effort is required. In some cases, the initial goal for 2014 was met early on so a new goal was set even higher. Appendix 17 shows the situation of those key figures in April 2014.

7.3.7 Results from the pilot

When this pilot was initiated the mentality was that many of the necessary changes and improvements would be hard to achieve. In many cases hard work was indeed required

and at the end of year 2014 some goals still haven't been reached. However, there was also great success with some of the mini-projects.

Order forecasting process was analyzed to find the root causes behind inaccurate forecasts from market areas. The project team decided that contacting the different market areas regularly and asking for their input more often would be helpful. Trends from forecasts should be used as an input for production. The ideal situation would be to give up forecasting for the most part and manufacture machines only for an actual need. That, however, is not what the product line and business unit management is willing to do. There's still a strong belief that there needs to be machines ready for immediate purchase when a customer need presents itself. More customer research would probably be helpful to determine if the customer need actually is that urgent that a machine has to be ready right away.

Order office lead time started from over 10 days but with process improvement and new guidelines the lowest recorded lead time so far has been 5,5 days. The average has been around 7-8 days. New systems for quotations and ordering have been implemented during year 2014 and are linked to SAP so in the future it will become even easier to lower the lead times and form a functioning process flow.

The first real success was the mini-project concerning material lead time. The starting point was a weighted average of 77 days. In a couple of months, the procurement was able to implement actions such as re-definition of the re-order points in SAP and pull control, and negotiations with the suppliers lead to better contracts. The weighted average dropped to 44,2 days in the spring of 2014. Many negotiations are still ongoing because there's still room for improvement in lead times and delivery accuracy.

Raw material inventory also had some clear actions from the beginning. The whole inventory was evaluated to find out the overstocking situation and the unnecessary parts were returned to the supplier, scrapped, or sold to spare parts department. During the spring of 2014 the inventory value decreased from 13 weeks' worth of inventory to a level of 9 weeks' worth. Procurement stopped ordering new parts until the old inventory was consumed. This will hopefully affect warranty costs in the future when the parts installed to a new machine are not too old to be claimed back from the supplier if they are damaged. Procurement still feels that some suppliers are too big to be negotiated with concerning lead times and batch sizes but the project management feels that they should still try to do all they can to improve the situation with these suppliers as well since the parts they supply make a big difference in the total inventory.

In production the engine assembly and final line assembly were re-organized to establish a better flow. This, however, didn't shorten the average cycle times but made the production line less vulnerable for disruption. In fact, the reorganizing measures lengthened the cycle time a little when the preparing stages are now a part of the work performed on the

assembly line. The line works in two shifts but there has been talk of changing it to three shifts to be able to get the machines out in a smaller number of days. Supplier quality assurance should in time affect the re-work costs positively and again cause less distractions in production. The outsourced work could not be completely eliminated at the time of this thesis because Tampere factory needed to make some changes into its finishing work stations. The goal still remained that as soon as possible this extra operation would be eliminated.

Finished goods inventory value is affected by the number of orders received in the calculation formula used in this value stream map. The average output from the factory (actual customer deliveries) increased from 2,9 machines per week to 3,6 machines per week. This and other actions taken up with distributors and Metso Sales and Service offices affected the lowering of the FGI value. Factory FGI in the spring of 2014 was 1,8 weeks' worth and SSO FGI 6,6 weeks' worth. In this mini-project some of the actions are still ongoing or being prepared. Those actions include creating a global inventory policy and establishing pull control for sales area stocks.

Renegotiating supplier payment terms as a mini-project didn't go forward with as much speed as the others. The goal of payment time of 60 days was 10 days higher than the target defined at the local factory level. It was also hard to find the responsible person to take care of this project. The people involved in the project team needed more effort from the upper level but it proved difficult to get the necessary people involved in this pilot. The same problem affected the mini-project of renegotiating customer payment terms. Even with time the project management was unable to find an owner for this mini-project. It seemed that this lean pilot was not yet sufficiently popular and well-known to attract attention from other departments that hadn't been involved from the beginning. Even the word 'lean' seemed to be a turn-off for some people.

In the summer of 2014 the project team stopped following-up the mini-project in bi-weekly meetings. The key figures are still collected monthly, actions are still going on, and another lean project with a different product group has been initiated in Tampere in June 2014. In the spring of 2014 One Factory initiated a search for applicants for the Lean Champions program and Tampere currently has their own lean champion who's leading the new project forward.

7.4 Second Lean pilot with product group Y

After the initiation of the first Lean pilot it was discovered that a value stream map revealed many problems in a product line's manufacturing and order-delivery process quite easily. That is why a second Lean pilot was announced and the chosen product line was product group Y manufactured outside Finland. And if successful, the second Lean pilot would also serve as a more convincing proof of concept. If it would be possible to achieve the same kind of discoveries as with the first pilot it would be proof that the results can

be replicated in other locations besides Tampere. And to convince other One Factory locations that the project team consisted of Finnish people is interested in the big picture and not just Tampere factory.

Product group Y consists of several products of which seven are manufactured at this chosen location. Products are sold mostly to the local market but some are also shipped overseas if necessary. Several products of product group Y are manufactured in other locations as well but the other locations were not a part of this second pilot.

7.4.1 Background

The reason for choosing product group Y as the second pilot projects was that it is a strategically important product line and market. Having a manufacturing facility in a growing market is vital if Metso wants to increase market share in that sales area. However, there is also a clear need for improvement especially with supplier and product quality and profitability. The basic idea in One Factory is that there exists a certain Metso quality of products and a way of working no matter which location the product is manufactured in.

Especially important was to try to create a common work culture in One Factory. These two locations of the two pilots were completely different. Is was important to test if the same methods would be useful in a whole other part of the world where the history and culture are quite different than what Finnish people are used to.

The sales process of this product group was somewhat different than in the first pilot. This location has three different routes of sales. They sell to domestic market by themselves, they serve another One Factory location in another country as a supplier and the machine sales to other countries is handled by Tampere. In appendix 18 are the monthly deliveries on 2013, the total and all the three different sales routes.

7.4.2 Value stream map

After initiating the first Lean pilot with product group X there was a working template ready for a VSM and it had already proven to be clear and efficient. Data collecting proved to be more difficult than in the first pilot because now all people involved with the project were no longer working in the same location. Time differences, cultural differences and language barriers all played a part in this project and made it more complicated to run smoothly. It was also discovered that several performance indicators were measured differently and it was harder to try to gather comparable data and replicate data sources and reports. It required a lot more support from the project team to the local team to get the right numbers to the value stream map. Of course one highly useful thing in the first pilot was the ongoing 5S project in which some of the project key group were also participating. In this other location there was no such projects going on so the lack of

basic training made it harder to understand what the project is aiming for. The local culture also played a significant part in why they weren't necessarily as enthusiastic in going forward with the lean transformation.

After a few weeks in the first project the team had gathered all initial data and was well on their way in defining problems in the value stream map. In the second pilot, however, things were different. After the first month the value stream map was at a state visible in appendix 19. A significant part of vital information was still missing and the project team in Tampere had some real difficulties in finding the responsible people on site in order to get these numbers for the map.

7.4.3 Selecting improvement projects

Collecting the data for a complete analysis took several weeks longer than in the first pilot and the kick off didn't happen as fast and with as much enthusiasm as it did with the first pilot. There was also very little input from the local team in the beginning and almost every idea had to come from the project team. Even though a lot of information was still missing the team wanted to go forward with the improvement projects in order to get the ball rolling. The team decided to replicate some of the mini-projects of the first pilot since some of the discovered problems were the same as with product group X. However, for some parts the whole process differed between the two product groups so much that there were no similarities.

The first thing to improve was the forecasting. Again, it is not a very lean approach to take but since it is a part of the way of working it was included here. The forecasting process is similar to the one with product group X so the problems were pretty much the same. The factory received orders from five main sources and the forecasts from those five were not ideal.

Order acknowledgement time reduction was the second improvement. The lead time of this process was already much faster than in the first pilot because the products were very different. This product group includes much less options and variations so it was easier to finalize the orders in a much shorter time which in this case was three days. However, since the product is much simpler the target should be a shorter lead time and trimming the process shouldn't prove too hard.

Material supply process was quickly found problematic. There were much too high raw material inventories, 15 weeks' worth for production. Supplier delivery accuracy was at a poor level and the costs of repairing faulty materials were notably high. There was also a global goal set for material lead time reduction. All these problems in production were affecting also the customer delivery accuracy which needed to be improved. The same kind of analysis of material lead time per material vs. demand (width) was executed with this this product group as was with the previous pilot. It is pictured in appendix 20.

Production process had room for improvement and it seemed possible to trim a couple of days off the total lead time. The WIP level also needed to be studied further to see if it could be reduced.

The level of FGI was high just like in the first project so again that needed some improvement. Also the local inventory turn was low so that needed some attention.

Standardizing the payment terms for both suppliers and customers seemed like a logical next step in improving the whole value stream. The average supplier and customer payment times were not at a poor level but the whole process seemed to be unclear as standard guidelines were missing and the local business culture proved to be very different than the project team was used to.

7.4.4 Defining targeted situation

After looking through the value stream map and evaluating the situation project management set goals for the mini-projects. Those goals were:

- Order acknowledgement lead time reduction (target set after root cause analysis)
- Improving supplier delivery accuracy to 80 %
- Improving customer delivery accuracy to 96 %
- Material lead time reduction of 10 %
- Raw material inventory reduction of 50 %
- Material quality improvement, reduce the cost of repairs by 50 %
- Production lead time reduction from 22 to 20 days
- WIP reduction if possible
- FGI reduction, increase inventory turn level to 5
- Standardize supplier payment times
- Standardize customer payment terms

These goals were then communicated to the local project team and the next step was to analyze the root causes and clearly define actions for making the necessary changes. The bi-weekly pilot steering sessions were arranged via video meeting system. It proved difficult to get all the necessary people to the same meetings and many times vital information was missing because someone was unavailable. Also because the local systems and ways of working were different it was very difficult to get comparable key figures to use in the analysis so this pilot didn’t go forward as quickly as the first one.

7.4.5 Handing the pilot forward

In Q2 of 2014 the Lean Champions program was kicked off and a two-part training seminar for the selected candidates was arranged. The project manager Pekka Ahokas also took part in it and one of the candidates was a person who was already involved in this

second pilot. Soon after that it was decided that the project would advance more efficiently of the local team would take more responsibility since they now also had their own trained Lean Champion.

After Q2 2014 this thesis was no longer an actual resource for this second pilot. The involvement was limited to providing some of the monthly key figures for their project follow-up. The project is still managed from Finland since the project manager is globally responsible for operational excellence and the factories are not in a lean state mature enough to operate everything on their own.

8 DISCUSSION

At the beginning of this thesis in One Factory there were only theories of lean read from several books and success stories written by different people in different kinds of organizations. After the initiation of the pilots it became clear that a literary study of lean is very easy compared to implementing the theories into practical use. There are so many popular books, articles, and internet communities concerning lean that it is almost too much. Limiting the reference material to only include the really essential information was the only difficulty with lean research. For this thesis the starting point was the *Lean handbook* by Manos et al. and also *What is Lean* by Modig and Åhlström. These two defined the point of view to be used in One Factory's lean transformation. The first was very much focused in using different tools, methods, and techniques in implementing lean in a work environment. It was also focused on a production environment which served the pilots quite well. The second was more focused on lean philosophy and implementing it in different kinds of workplaces and even service industry. So with these two views the transformation began.

From the beginning it became clear that not everyone is so easily willing to jump right into a lean transformation initiative when it differs so much from what has been done before. The resistance to change came as a surprise even though in almost every literary source it is highly underlined as the number one reason for lean transformation failures. For some, even the word lean is a turn off and for some others the whole concept seems so confusing in the beginning that they don't want to hear any more of it. Lean is not a new philosophy and of course there are many examples of it not being implemented successfully. The important thing is to keep an open mind and study the successes and failures of others to avoid the same mistakes from happening in One Factory.

When working with factories in different countries and continents some resistance was expected. The fact that the origins of lean come from Toyota in Japan caused some prejudice which wasn't necessarily anticipated since hardly anyone can deny the success of Toyota. Many of the more recent lean success stories originate from western countries in Europe or from the United States so it's already been proven that lean can work in other cultures as well. Sometimes it also felt like some people had heard too many rumors of unsuccessful attempts of lean implementation and that caused mistrust that it would work in Metso's case. In those cases, the focus was too much on the negative when everyone should be looking for ways to improve with a positive attitude.

When the first pilot began at the turn of the year 2014 the biggest problems weren't with the fact that the project management was trying to implement a foreign philosophy. It was that it was a new philosophy that differs greatly from what has been done so far. The factory in Tampere has a long history and it's celebrating its 100th birthday in the spring

of 2015 so some things have always been done in a very traditional way. One example in which this thesis or the whole pilot wasn't able to affect was manufacturing based on forecasts. During the pilot manufacturing became less dependent on the forecasts but they still exist and they still have an impact. Sometimes it was also frustrating to understand how slowly change can be achieved and how small steps the team had to take when implementing changes. All in all, the first pilot was a great learning experience. It was also very rewarding to see the results that the team was able to reach in a little less than a year. All the lessons learned during the first pilot would be very useful in all the future lean projects and pilots. And some things that didn't work so well this time might work in some other projects. Even though the project team faced slow phases when it seemed nothing was moving forward the overall experience was a positive one.

The second pilot in the beginning of 2014 didn't start out as smoothly. It seemed there was some mistrust from the local team when a Finnish project management group was in their point of view trying to enforce a Japanese philosophy into a very different organizational culture. That culture was very different from what Finnish people are used to so it came as a bit of a surprise. Because this location was so far away meeting face to face weekly, bi-weekly, or even once a month wasn't an option. The project manager travelled to site at an early stage of the pilot but a short visit didn't help that much. The project team soon learned that this type of a lean project needs to be managed locally, not from a great distance. Real and long discussions via video meetings are not possible and the language and cultural barriers make it even more difficult. And when this particular location got their own Lean champion candidate it was logical to make that person the local leader of the project. They still need to report to the project manager in Finland but things are running more smoothly now that someone is involved in all the day-to-day routines in the factory.

8.1 Analysis of the One Factory Lean project

In retrospect, what could have been done better or what could have made things run a little more smoothly is involving more people in the pilots. Sometimes the problem was that the key people who should have been involved were too busy or not interested enough to join the bi-weekly meetings and discussions. Sometimes the people involved in the project group weren't authorized to make big enough changes and they had to get permission from someone else. That someone else wasn't always willing to be a part of a lean pilot and that caused some delay in getting things moving and improvements done. That sometimes caused a decline in the group's motivation and it felt nothing was happening even with all the efforts of the group members. Again the problem was lack of commitment from the whole organization. With a lean transformation all parties should be involved and committed from the very beginning. In this case the commitment started to grow only whit successful pilots but the problem is that the pilots could have been even more successful with the organization's full support and involvement.

Since the initiation of the Lean champions program other pilots have seen daylight in other One Factory locations. Now that two of the pilots are in a mature state comparing the new pilots and their starting points to those two make things easier to plan. It will be very interesting to see how much improvement can be achieved with all these new projects and if that improvement can be reached in a shorter time period now that the company and project manager already have experience from managing a lean project and the level of commitment has improved. Criticism can be expected and even welcomed at certain points but everyone involved should focus on finding the solutions that work for One Factory instead of focusing on the problems and negative thinking. Lean can become a part of the Metso brand in mining and construction industry and its possible value should not be underestimated.

Since One Factory's experience with lean is still somewhat limited the usage and functionality of the toolbox remains to be seen. Many of the tools were of course utilized during the pilot projects but the rest still need to be tested and used in an actual work environment. What the toolbox is trying to achieve is a way of thinking where one must go and see for themselves. All the tools and methods are pointless if one does not have a clear understanding of the current state and what kind of improvements are needed. Some of the tools might seem a little too simple but people using them shouldn't focus too much on that. The truth is that sometimes at work people make things too difficult and try to solve problems in a complicated way. Sometimes one needs to take a step back and look at the simple things one can see and observe just with their own eyes. The most obvious problems are easy to fix first before moving on to more complicated and detailed problems. That is what continuous improvement is all about, the work never stops.

8.2 Recommendations for further actions

When it comes to successfully implementing lean the most important things are commitment and sufficient training. The lean champion program is absolutely a step in the right direction but it's still a baby step. What One Factory is clearly missing is companywide lean awareness throughout different organizational levels. The lean way of working should become a company standard but all departments need to be aware of lean basics. That information should be spread in many ways of communication, global and local intranets, other publications, training, and management routines. All managers should be trained and they should then train their subordinates and show them the new, lean way of thinking.

Currently the production staff is already quite familiar with lean and the routines have been re-organized towards a leaner approach. Visual management can be noticed by walking in One Factory production environment, new tools and techniques are used in procurement, error-proofing, and other everyday actions. However, there are many departments in One Factory, mostly in an office environment, who have no grasp of what lean is and what it means in One Factory. The different lean roles presented by S A Partners

in figure 27 on page 74 are Lean awareness – Lean Team members – Lean Team Leaders – Lean Champion – Lean Master. To achieve a successful lean transformation One Factory needs to take a close look at how these different roles are applied in the whole organization. What's obviously missing is lean awareness since it is required from anyone working within the organization. This is the most important step to achieve in the near future as it is the basis of a lean organization. One Factory already has people that can be described as Lean Team members but seeing that it is the second level of the pyramid there needs to be many more. That naturally requires more training and involving the employees more in taking part in problem solving and improvement efforts. Investing in training is absolutely necessary if the organization is serious about completing the transformation.

The three remaining levels of the pyramid are also still incomplete in One Factory. Lean Champion program included workshops for training and evaluation of personal skills. Currently this team of individuals along with the project manager responsible for operational excellence has received the most lean training in One Factory. It is very likely that in time they will become the Lean Masters of One Factory. All new pilots and improvement projects give more information to the organization and the key people and in the future these people will truly become experts if they just continue to apply the lean principles.

In the beginning of 2015 in Tampere the office workers got a taste of lean when a 5S clean-up day was organized by upper management in Tampere central office. It was presented as a way of making work more efficient and establishing a flow by eliminating all the chaos from one's office or work station. All unnecessary paper and other waste was placed in recycling bins and work stations were re-organized to have only the necessary materials available at all times. While this was a good exercise to have, lean for the office needs to be implemented in a wider scale. When lean is linked to the company's strategy and key objectives it shouldn't be too hard to utilize lean in an office environment. The basic idea is always the same; creating value for the customer. It doesn't matter whether it's an external or an internal customer but one should think of the customer as a production unit flowing through the process. Making the customer wait creates no value for them and never adds to their overall satisfaction.

Currently the problem is that what is advertised in company publications are the tools and methods used in production and that is branded as being lean. What's missing is an easy to understand explanation of the ideology behind the transformation. It is still very unclear for many people why One Factory has decided to utilize lean in their organizational transformation. In order to get everyone committed the goals should be clear to everyone. A factory environment is often filled with old-fashioned views on production and the workers lie doing things the way they've always been done. That is why it is important to make

the lean communication and training as inspirational as possible. There's no need to always use an external consultant when the message can be relayed by a familiar face who is committed and has an enthusiastic approach towards lean.

If the lean transformation of One Factory moves forward as planned there are several other advantages besides the obvious improved resource and flow efficiencies and cost savings. The whole industry is always interested in hearing success stories of others so by succeeding in this transformation could gain Metso and One Factory some very useful media coverage. Other organizations will want to benchmark what has been accomplished and students will want to learn and study the process behind this success even further. There's also a very good chance that this type of success would make Metso even more desirable employer in the eyes of experts of this industry and also in the eyes of production and industrial engineering students. The possibility of becoming one of the forerunners in the industry should be taken as a serious opportunity.

9 CONCLUSIONS

This thesis was set out to help study if lean can be successfully implemented in Metso One Factory. From the beginning, the structure was divided in two parts: the theoretical study and the practical application. The theoretical part was supposed to consist of a Lean Toolbox and setting up a management system. The practical application consisted of two pilot projects initiated at the time of this thesis's creation.

Lean tools and techniques study was easy to execute since it was done independently and the main reference material was determined by the project manager. As the study was done simultaneously with the pilot projects it was easy to see right away the tools that would be the most popular in this environment. Also, being at a beginning stage of a lean transformation it was easy to exclude some of the studied production fine tuning tools. The contribution of the whole Toolbox still remains to be seen but some of the templates have already aroused the interest of other departments and they have been openly shared with anyone interested. The instructions and actual templates seem rather easily understood and used so they can be counted as a success.

Setting up a management system was the part of this thesis that was left with less attention. When the project went on it became clear that with the theoretical study and the ongoing pilots there wouldn't be sufficient time to start drafting a complete management system for One Factory Lean with the project manager. And drafting such a system independently really wasn't in the thesis worker's sole discretion. That is why this part of the thesis was changed into a suggestive chapter about the guidelines for this type of management system. If the original approach would have been doable it would have made limiting the accurate topic of this thesis a lot harder. Drafting a complete management system would have meant that something else would have needed to be left out so in retrospect it was a good decision not to follow the original plan. The two pilot projects were the most interesting and educational parts of this thesis. Even with all the problems faced on the way they lead to real results and improvements. They also made a real difference in the way people work in One Factory at least for those involved with the selected product groups in the selected locations. The two first pilots lead to more pilots and the lean champion program so they did what they were supposed to do: acted as a proof of concept. If there would have been more time available, it would have been interesting to follow and work for the next pilots as well. The second pilot was given to the local team to manage which in lean point of view was the right decision. The third pilot began in Tampere as well but it was past the duration of this thesis work.

As a conclusion, one out of the three original goals was reached very successfully and that was the contribution to the pilots. The second goal which is the Toolbox was reached partially and in the future we will see its true usefulness. The third goal was altered during

the process to make more sense in this context. It is the suggestion of the thesis worker to the company on how to start building a management and facilitating system for One Factory Lean.

REFERENCES

Ballé, M. 2014. 7 Steps for Leading Lean with Respect for People. [WWW]. [Accessed on 10.2.2015]. Available at: http://www.industryweek.com/lean-six-sigma/7-steps-leading-lean-respect-people

Byrne, A. 2013. The Lean Turnaround: How Business Leaders Use Lean Principles to Create Value and Transform Their Company. McGraw-Hill. 272 p.

Capacent. 2013. Management consulting training materials.

Fabrizio, T., & Tapping, D.. 2006. 5S for the Office: Organizing the Workplace to Eliminate Waste. Productivity Press. 192 p.

Frost, T., Gottstein, H., Greiser, C. & Zinser, M. 2011. How to Become a Lean Champion. The Boston Consulting Group, Inc. Vol. 9/11. 14 p.

Gunasekaran, A. 2001. Agile Manufacturing: The 21st Century Competitive Strategy. Elsevier Ltd. 1. painos. 820 p.

Hines, P., Found, P., Griffiths, G. and Harrison, R. 2011. Staying Lean: Thriving, Not Just Surviving, Second Edition. Auerbach Publications. 282 p.

Hobbs, D. P. 2004. LEAN Manufacturing Implementation: A Complete Execution Manual for Any Size Manufacturer. J. Ross Publishing. 224 p.

Imai, M. 2012. Gemba Kaizen: A commonsense approach to a continuous improvement strategy. 2nd edition. McGraw-Hill. 426 p.

Kaizenworld. 2015. Kaikaku. [WWW]. [Accessed on 26.10.2015]. Available at: http://www.kaizenworld.com/kaizen-blog/kaikaku.html

Keyte, B., and Locher, D. 2004. The Complete Lean Enterprise: Value Stream Mapping For Administrative And Office Processes. Productivity Press. 136 p.

Kouri, I. 2010. Lean taskukirja. Teknologiateollisuus ry. 38 p.

Lean Enterprise Institute - Principles of Lean. 2009. [WWW]. [Accessed on 10.1.2014]. Available at: http://www.lean.org/

Lean Lexicon 5th edition. Lean Enterprise Institute. 2014. [WWW]. [Accessed on 24.6.2014]. Available at: http://www.lean.org/Common/LexiconTerm.aspx?termid=242

Liker, J. 2004. The Toyota way: 14 Management principles from the world's greatest manufacturer. 1st edition. McGraw-Hill. 330 p.

Manos, A. & Vincent, C. 2012. The Lean Handbook: A guide to the bronze certification body of knowledge. ASQ. 411 p.

Maskell, B., Baggaley, B. & Grasso, L. 2012. Practical Lean Accounting: A Proven System for Measuring and Managing the Lean Enterprise, Second Edition. Auerbach Publications. 482 p.

Modig, N. & Åhlström, P. 2013. This is Lean – Resolving the Efficiency Paradox. Rheologica Publishing. 167 p.

Ohno, T. 1988. Toyota Production System: Beyond Large-Scale Prodcution. CRC Press. 143 p.

One team, one goal – One Factory. 2012. Referred 8.1.2014. http://avenue.metso.com/News/Global/Pages

Raj, D., Rehse, O. 2012. Lean Services, A Primer for Success. The Boston Consulting Group, Inc. Vol 11/12. 13 p.

Rocher, D. 2013. Practicing lean fundamentals in an office environment. [WWW]. [Accessed on 15.3.2015]. Available at: http://www.lean.org/common/display/?o=2215

Rother, M. & Shook, J. 2003. Learning to See: Value stream mapping to create value and eliminate muda. Lean Enterprise Institute. 112 p.

S A Partners. 2013. Lean consulting training materials.

Tapping, D. 2008. The Simply Lean Pocket Guide: Making Great Organizations Better Through Plan-Do-Check-Act (PDCA) Kaizen Activities. MCS Media. 240 p.

Tapping, D., & Smith, M. 2009. The New Lean Office Pocket Guide: Tools for the Elimination of Waste in Paper-Based and Electronic Workflow Environments!.MCS Media.

Wilson, L. 2010. How to implement Lean Manufacturing. McGraw-Hill. 336 p.

Womack, J. & Jones, D. 2005. Lean solutions: How Companies and Customers Can Create Value and Wealth Together. Free Press. 396 p.

Womack, J. & Jones, D. 2003. Lean thinking: Banish Waste and Create Wealth in Your Corporation. Simon & Schuster. 396 p.

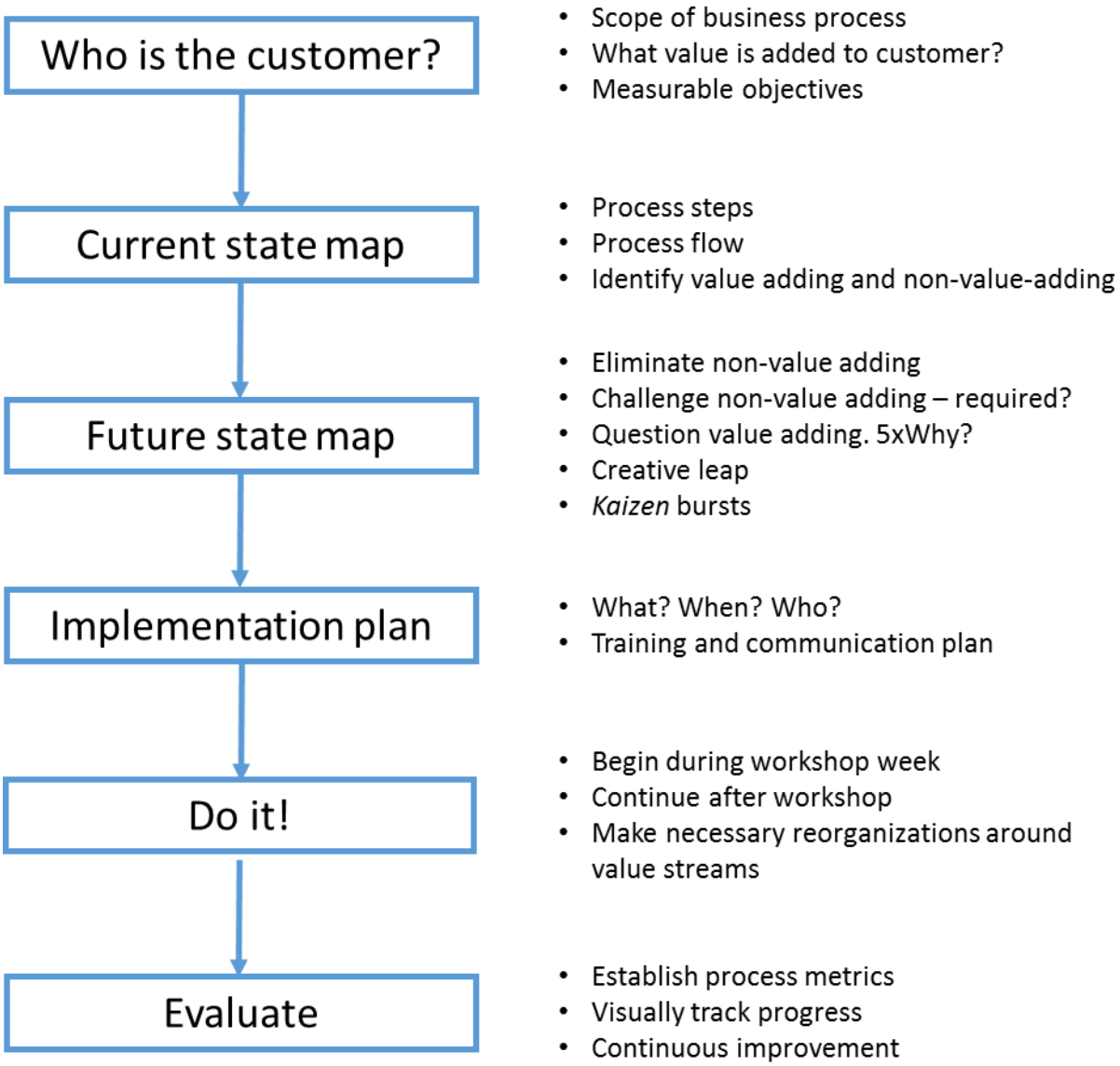
APPENDICES

Appendix 1. Kaizen workshop

Preparations:

1) Define the scope clearly enough
2) Process owner needs to set measurable objectives for the team
3) A preliminary current state value stream map needs to be created
4) Collect all relevant documents
5) Post the preliminary current state map in the team's meeting room

Workshop agenda:



Appendix 2. Waste walk

Waste type	Definition	Examples of own actions
Overproduction	Production beyond immediate customer needs or producing something before it is needed.	
Waiting	Any downtime that a person or product uses waiting for material, information or other people.	
Motion	Any motion including walking, bending, reaching and moving objects, that doesn't add value to the end product.	
Transportation	Transportation of any material, paper or information including transmission, transfer, transportation or lifting.	
Over-processing	Doing more to the end product than the customer requires.	
Inventory	Any number of parts or material that is in the system but isn't being processed.	
Defects	Any defect in process, product, material or service.	

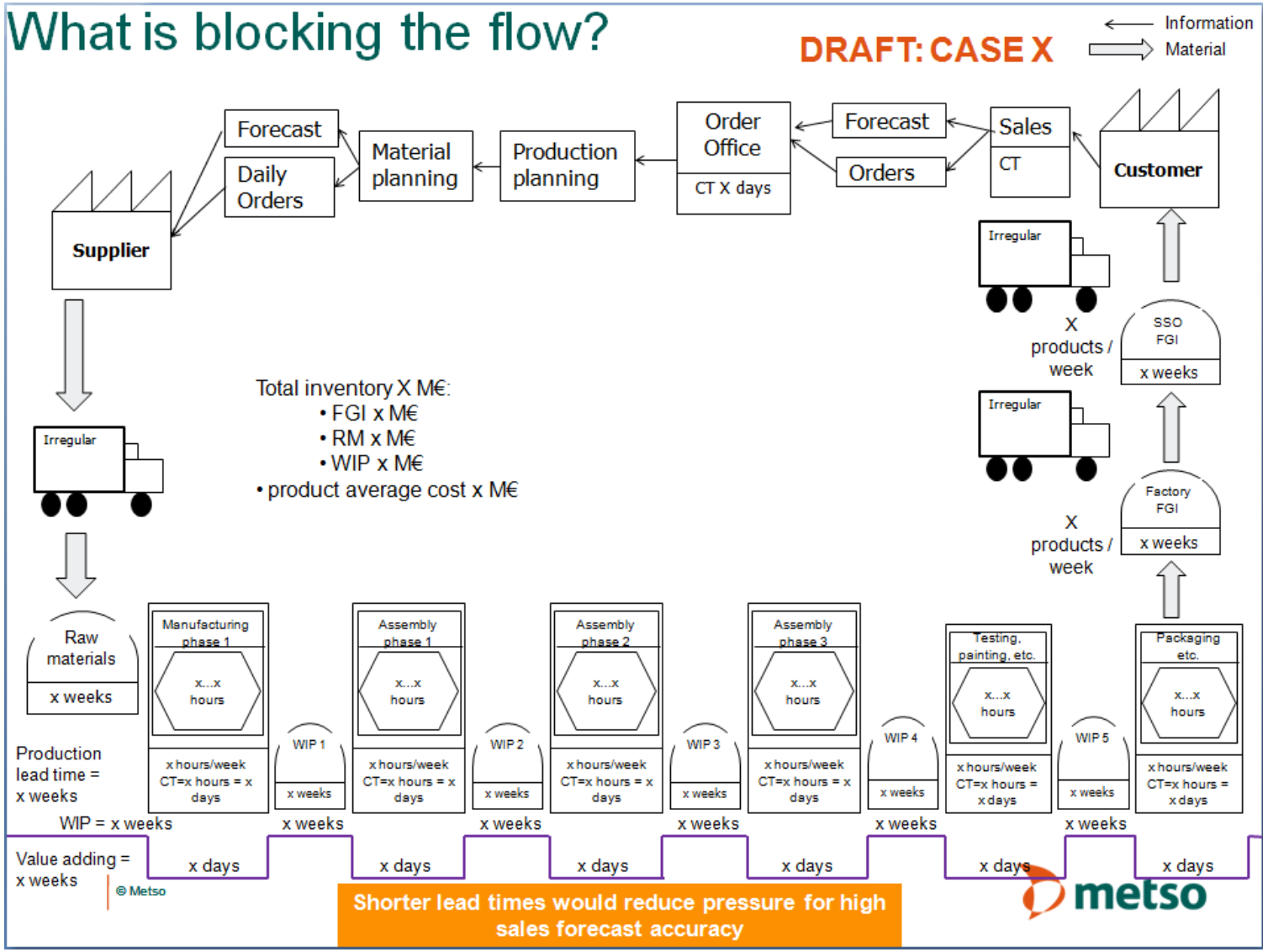
Observed waste	Waste type	Suggestions

Appendix 3. 5 x why

Ask the question why for as long as you find the root cause.

An example:		
The machine doesn't start. (The symptom)	The symptom:	
Why? – The battery is dead.	Why?	
Why? – The generator's not working.	Why?	
Why? – The drive belt has broken.	Why?	
Why? – The drive belt's a wear part and it wasn't replaced on time.	Why?	
Why? – The service schedule wasn't maintained. (Root cause!)	Why?	
	Why?	
	Why?	
	Why?	
	Why?	
	Why?	

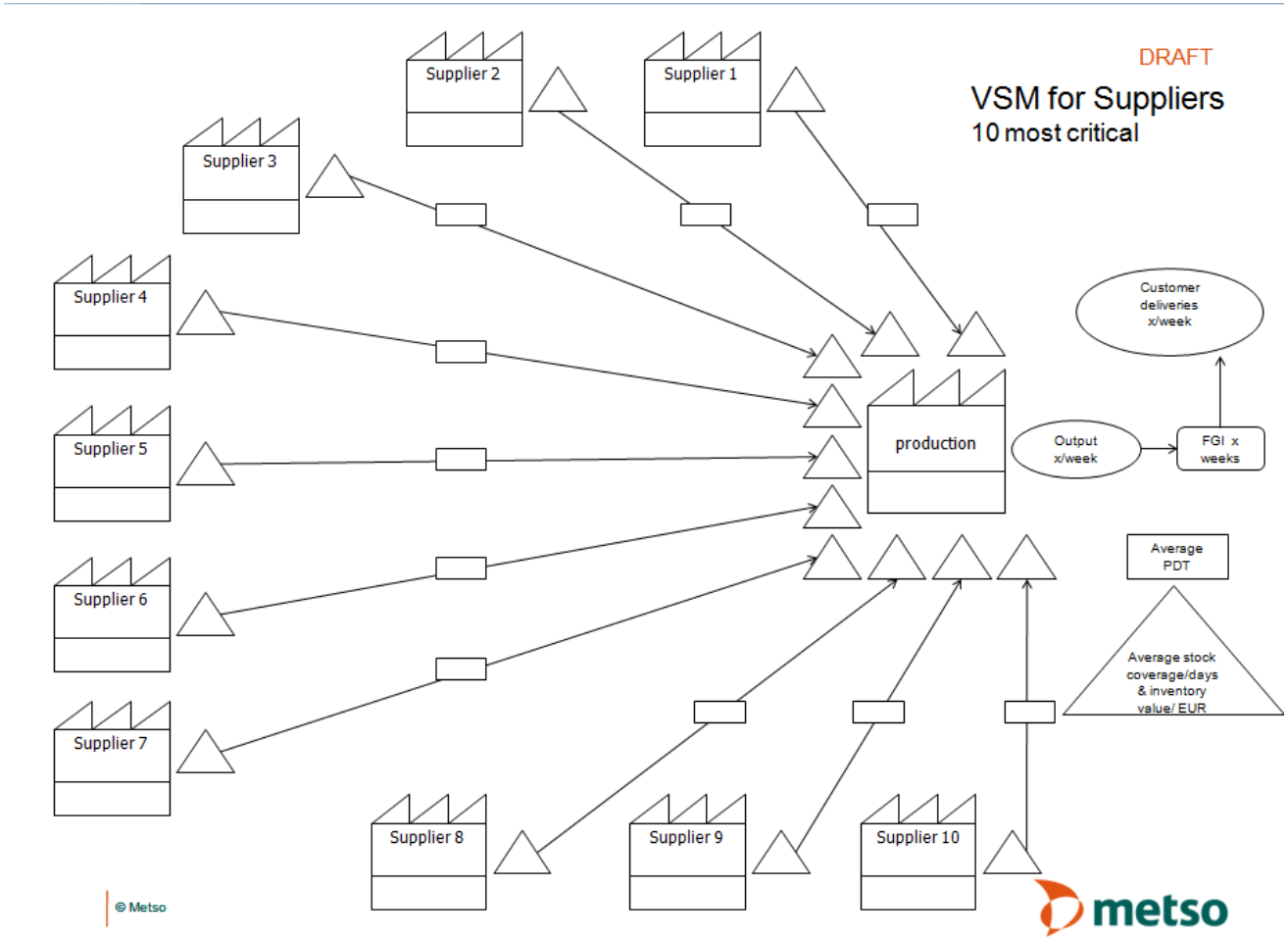
Appendix 4. Value stream map Template



Instructions for completing the Value stream map:

1) Raw materials (RM), monetary value of inventory → material ready for how many machines (based on inventory value vs. average machine cost) → change into days based on average machine output
2) WIP (Work In Progress) , monetary value of inventory → material ready for how many machines (based on inventory value vs. average machine cost) → change into days based on average machine output
3) FGI (Finished Goods Inventory) , monetary value of inventory → how many machines ready based on FG inventory vs. average machine cost → change into days based on average machine output

Appendix 5. Supplier Value stream map Template



Choose approximately 10 most critical suppliers (based on weighted average of inventory value and planned delivery time)

Triangles: Average stock coverage/days and inventory value/EUR

Squares: Average planned delivery time

Appendix 6. A3 – project management tool

Project plan:	Owner:
Background	**Proposed counter actions**
Current condition	**Plan**
Goals/Targets 1) 2) 3)	**Schedule**
Root cause analysis 1) 2) 3)	**Follow-up**

Appendix 7. 5S methodology

SORT

Divide all items in a workplace into three categories:

1) needed now in the work area → keep

2) not needed now in the work area → place in close proximity of the work area

3) not needed in the work area → remove from the work area

SET IN ORDER

Find a specific and logical location for all the items kept in the work area.

Daily use → keep close by

Used every now and then → keep a little farther away

Use visual aids to make the location obvious!

SHINE

Keep an eye on potential hazards which can disrupt the process and risk safety factors.

Make a clear list: Who's responsible for cleaning what, when & how.

Make sure necessary equipment is easily available: For example a cleaning cart.

STANDARDIZE

Create a policy for performing the three previous tasks: Sort, Set in order & Shine.

Make it easy enough to be followed on a daily basis.

SUSTAIN

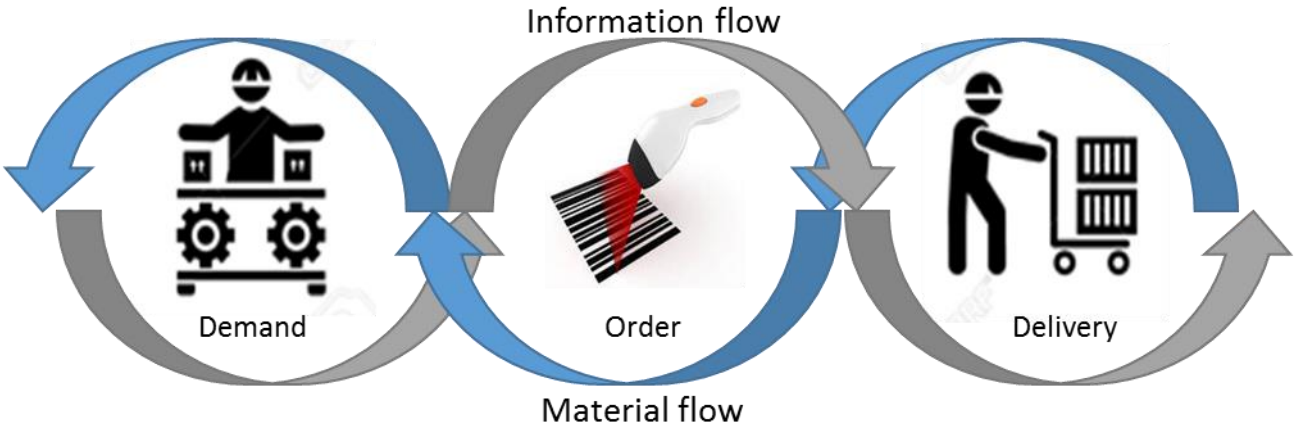
Maintain all the previous efforts.

Implement them as a part of the daily routines.

Organize audits and benchmarking tours.

Appendix 8. Kanban

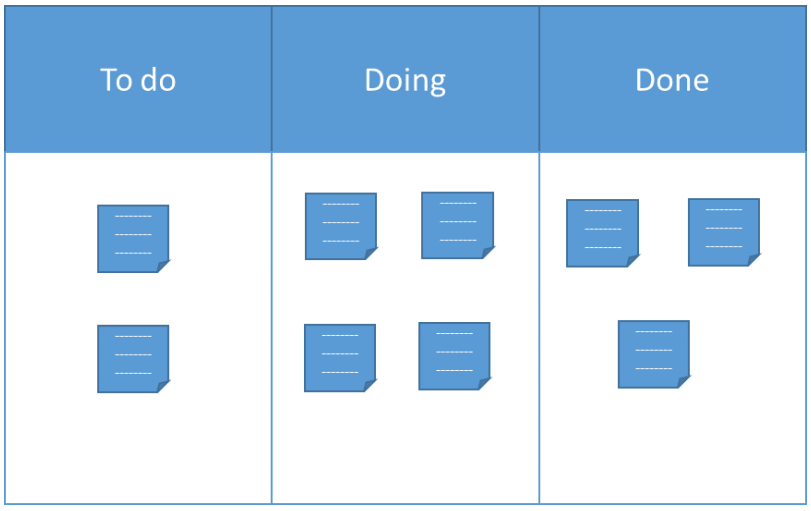
An *eKanban* process:



A *Kanban* card for materials:

Part description				**Part number**	
Qty		**Lead time**		**Order date**	
Supplier				**Due date**	
Planner				**Card 1 of 2**	
				Location	
Bar code					

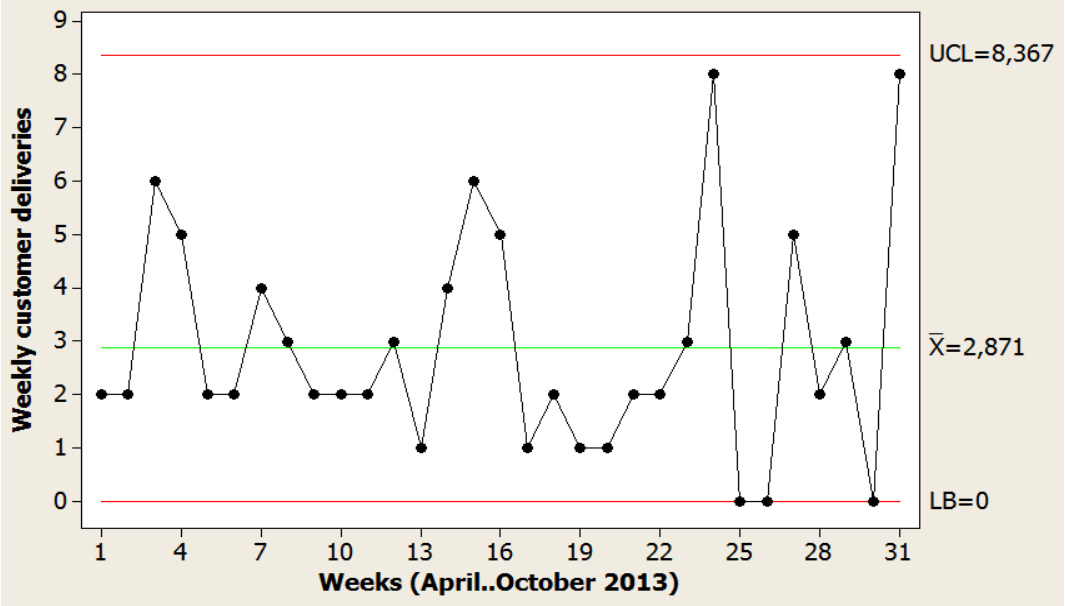
A simple *Kanban* board:



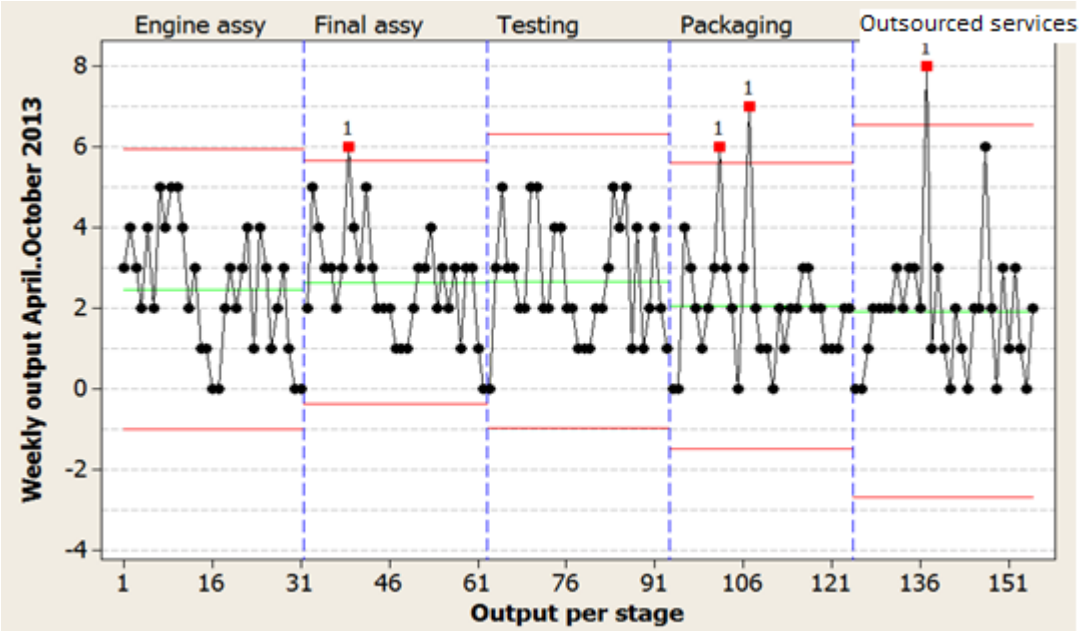
Appendix 9. Weekly outputs for product group X

Product group X

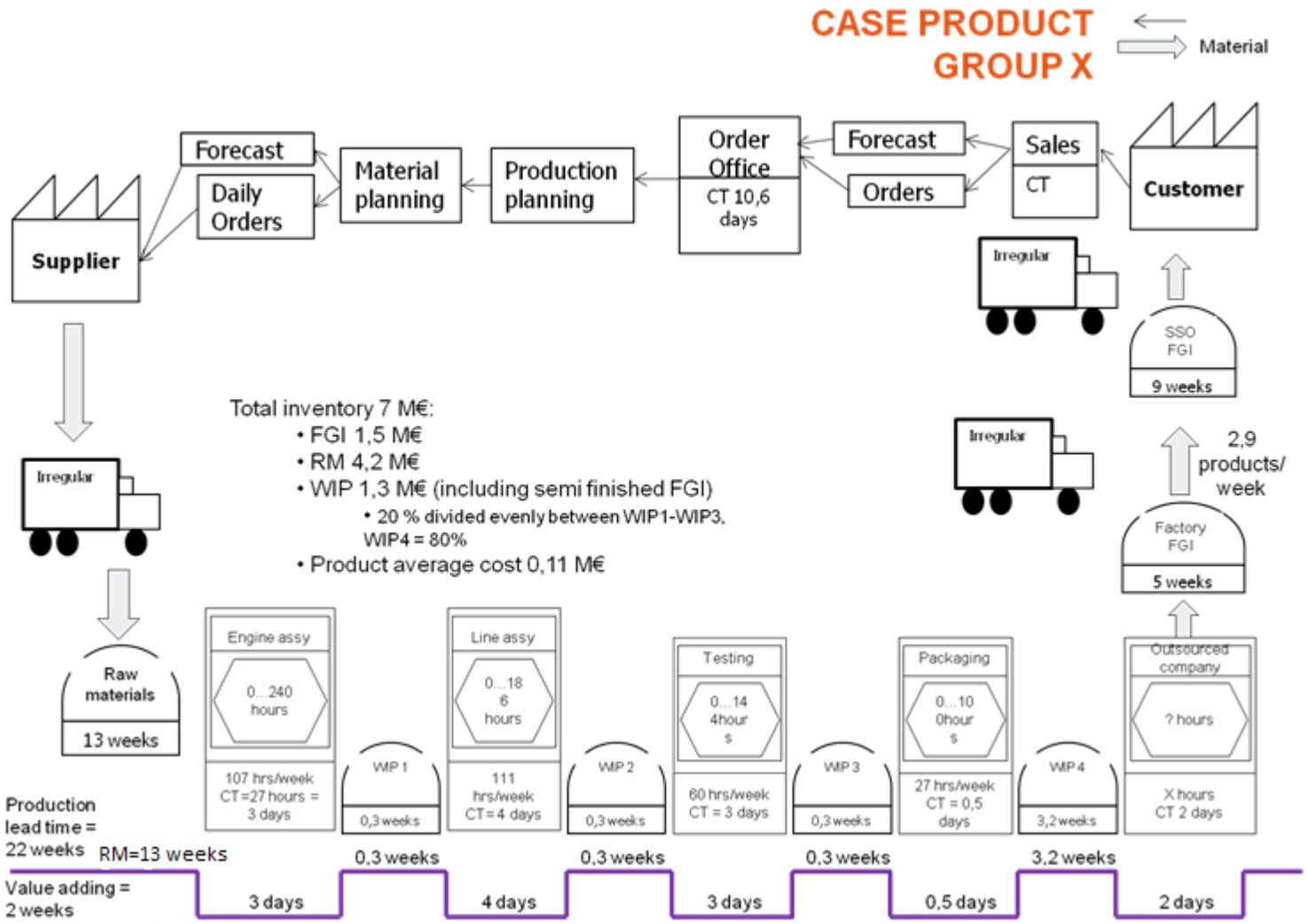
Customer deliveries per week:



Weekly output per production stage:

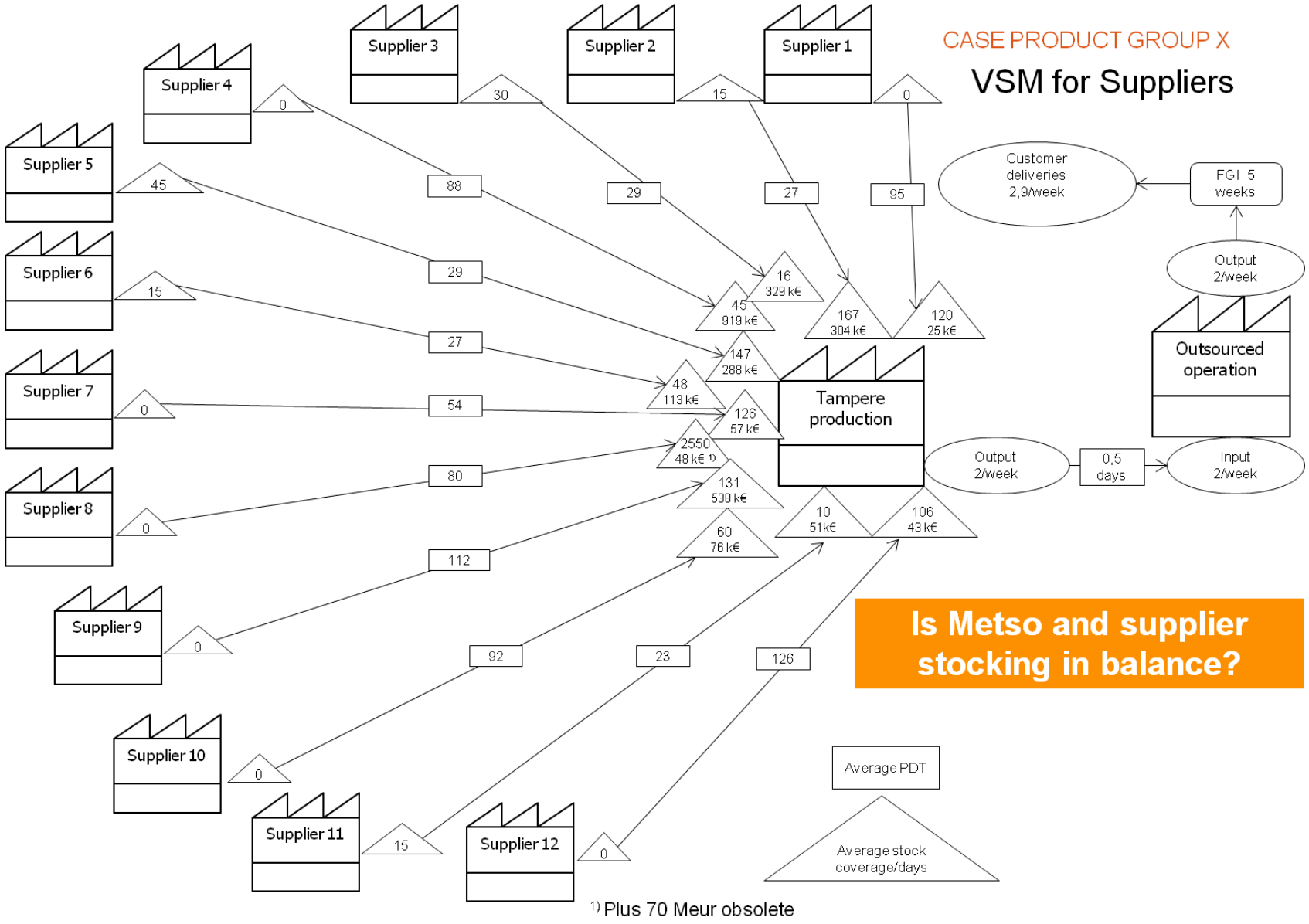


Appendix 10. Initial value stream map for product group X

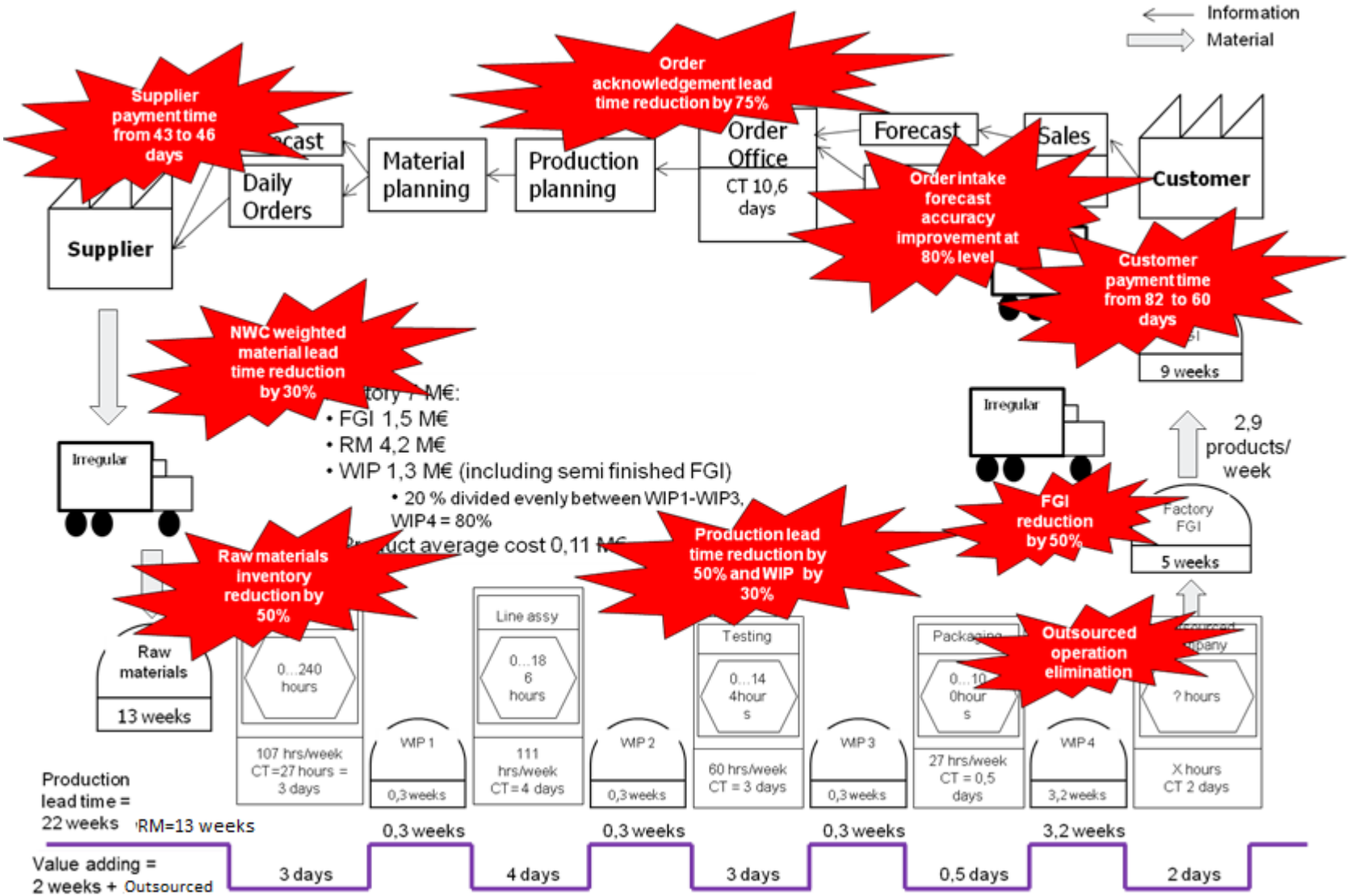


- Original lead time calculated from SAP, inventory value calculations explained in appendix 4

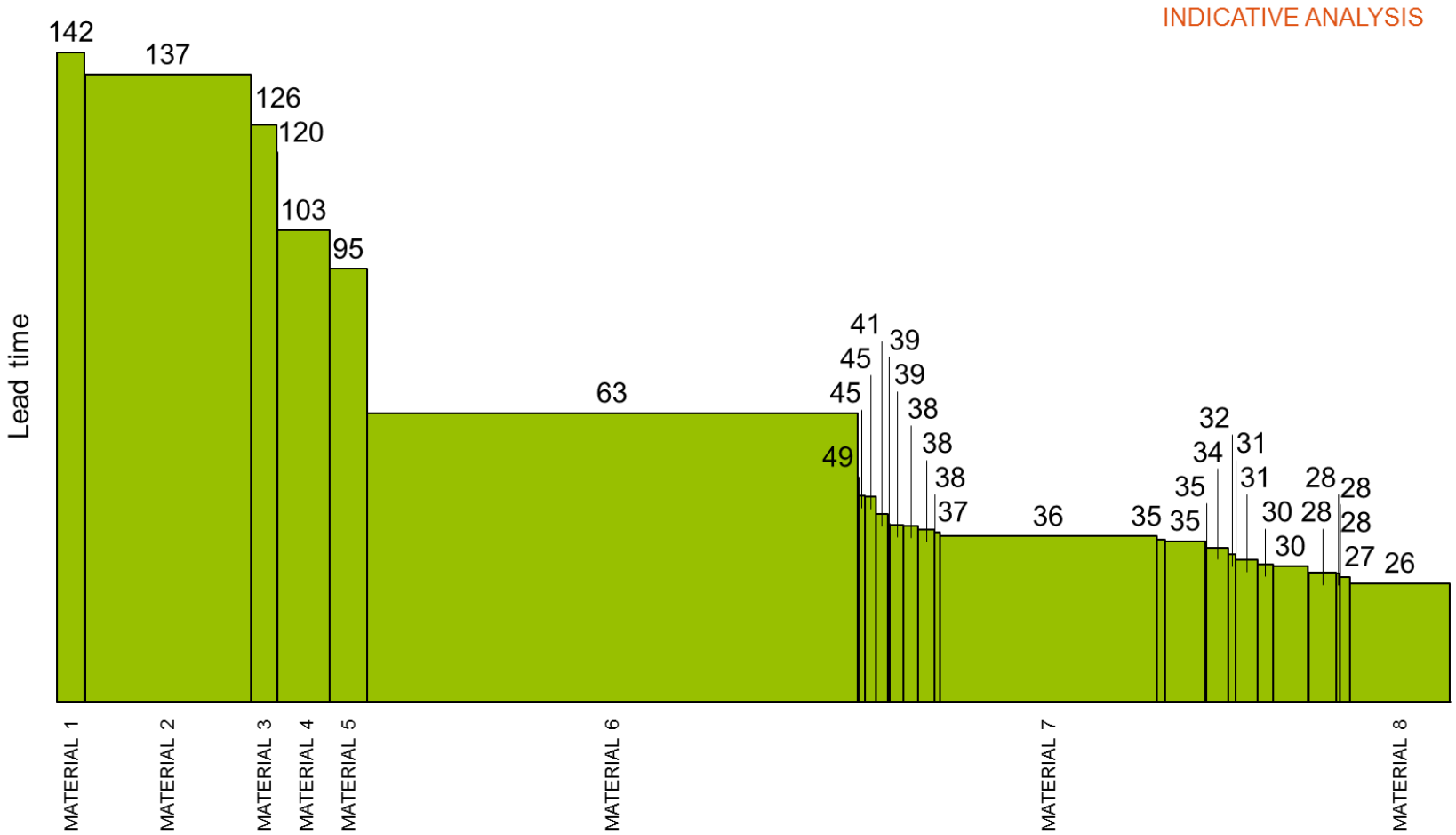
Appendix 11. Supplier Value stream map for product group X



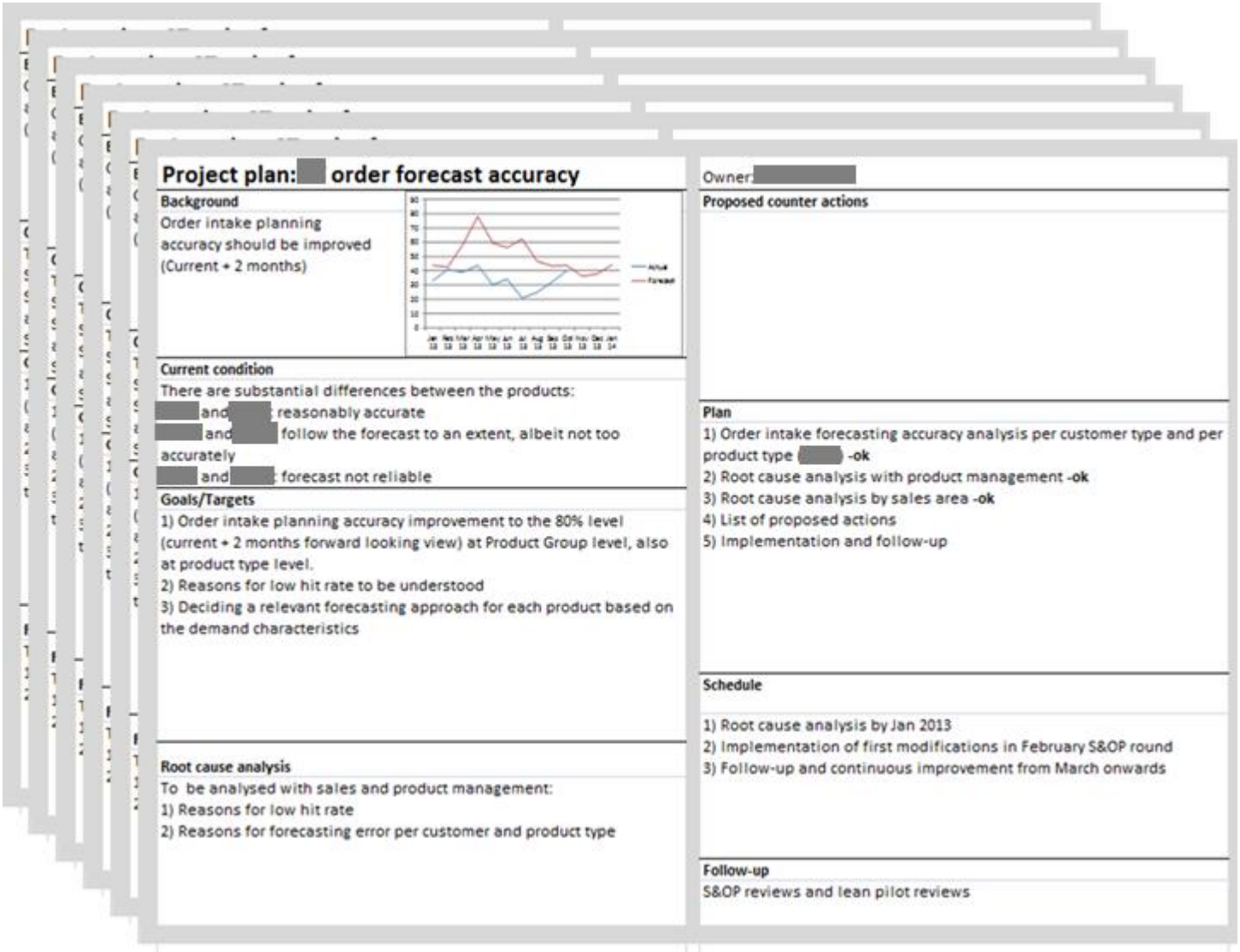
Appendix 12. Product group X selected improvement projects



Appendix 13. Product group X material lead time per material vs. demand (width)



Appendix 14. Product group X improvement projects



Project plan: [redacted] order forecast accuracy

Background

Order intake planning accuracy should be improved (Current + 2 months)

Current condition

There are substantial differences between the products:
[redacted] and [redacted]: reasonably accurate
[redacted] and [redacted] follow the forecast to an extent, albeit not too accurately
[redacted] and [redacted]: forecast not reliable

Goals/Targets

1) Order intake planning accuracy improvement to the 80% level (current + 2 months forward looking view) at Product Group level, also at product type level.
2) Reasons for low hit rate to be understood
3) Deciding a relevant forecasting approach for each product based on the demand characteristics

Root cause analysis

To be analysed with sales and product management:
1) Reasons for low hit rate
2) Reasons for forecasting error per customer and product type

Owner: [redacted]

Proposed counter actions

Plan

1) Order intake forecasting accuracy analysis per customer type and per product type ([redacted]) **-ok**
2) Root cause analysis with product management **-ok**
3) Root cause analysis by sales area **-ok**
4) List of proposed actions
5) Implementation and follow-up

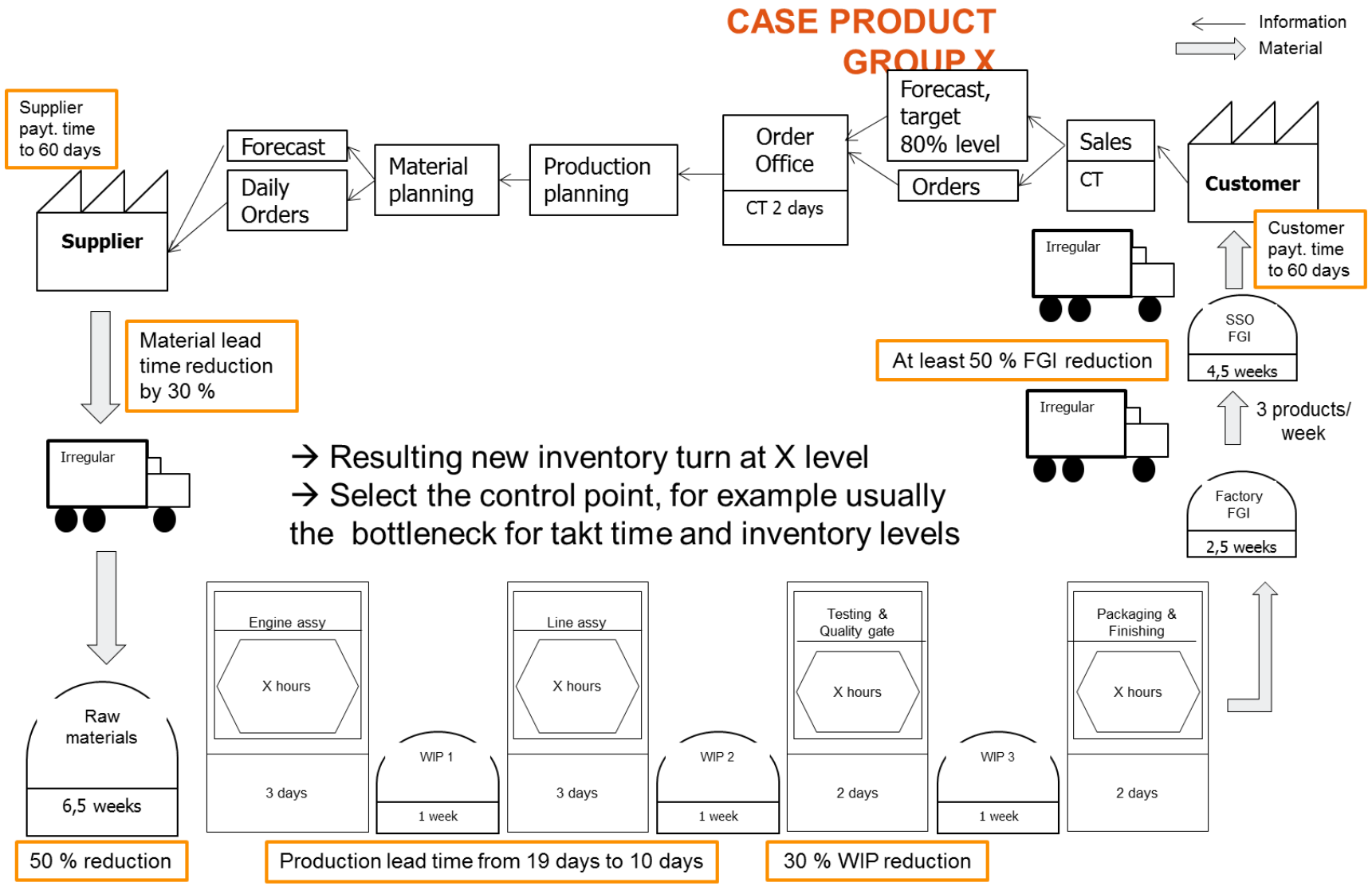
Schedule

1) Root cause analysis by Jan 2013
2) Implementation of first modifications in February S&OP round
3) Follow-up and continuous improvement from March onwards

Follow-up

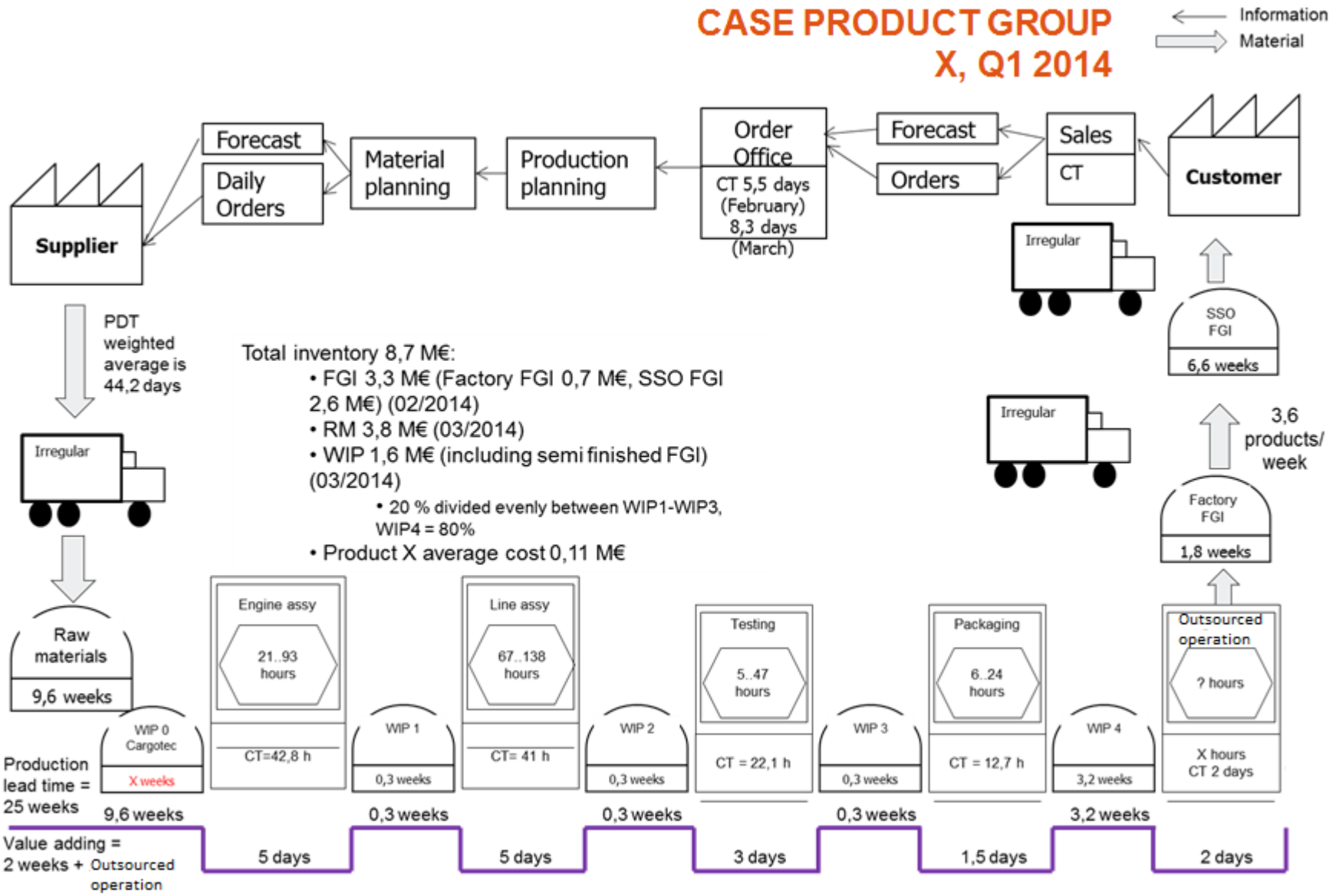
S&OP reviews and lean pilot reviews

Appendix 15. Target state value stream map for product group X



- All WIP in process divided evenly between WIP1-WIP3 leading to a total of 30% reduction

Appendix 16. Value stream map for product group X in Q1 2014



Appendix 17. Lean business targets

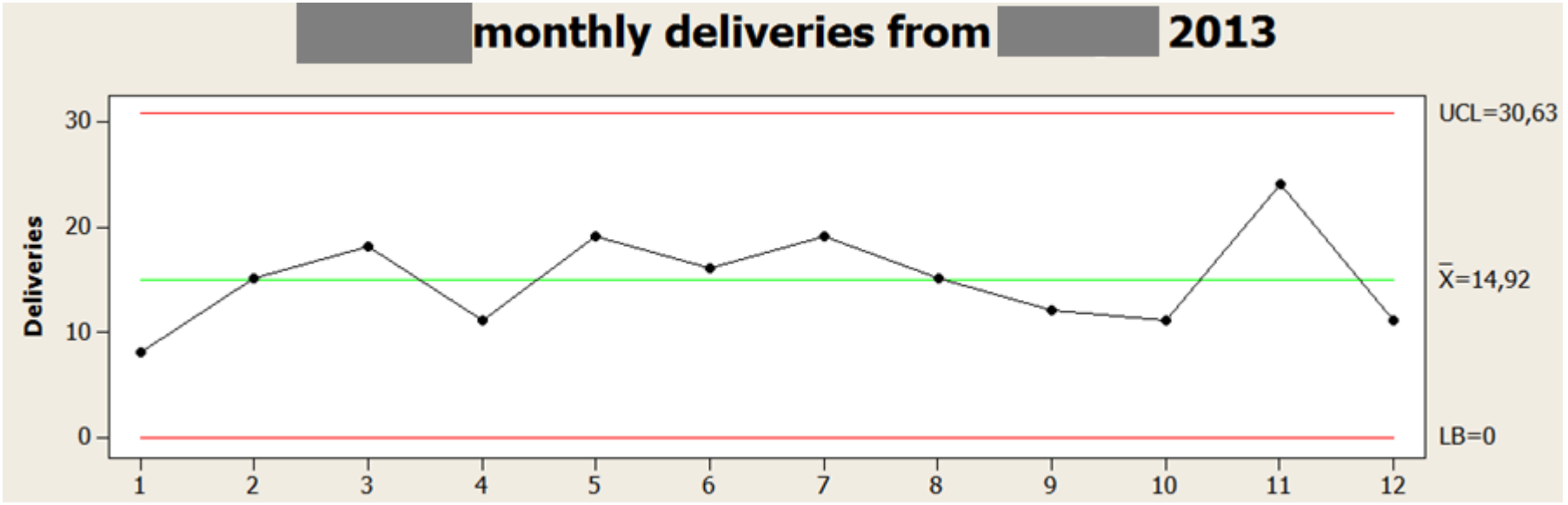
CSE Product group X KEY FIGURES	Actual 2013	Actual 2014 Jan	Feb	Mar	Apr	Target 2014	New Target 2014	Source	KPI Owner
Net Sales (MEUR)	X	X	X	X	X	X		X	X
Gross Profit %	X	X	X	X	X	X %		X	X
Inventory turns (CSE level)	X	X	X	X	X	X		X	X
Inventory turns (Tampere plant)	X	X	X	X	X	X		X	X
Total inventory value	X	X	X	X	X	X		X	X
- Components	X	X	X	X	X	X		X	X
- WIP	X	X	X	X	X	X		X	X
- FGI	X	X	X	X	X	X		X	X
Material Lead Time (days)	X	X	X	X	X	< X		X	X
Supplier Payment Terms	X	X	X	X	X	> X		X	X
Customer Payment Terms (6 month rolling avg.)	X	X		X		< X		X	X
Re Work Cost (TEUR)	X	X	x	X	X	X	X	X	X
Cost of Non Quality (% of monthly NS)	X	X	X	X	X	< X %		X	X
Product Cost X1 (TEUR)		X	X	X	X			X	X
Product Cost X2		X	X	X	X			X	X
Product Cost X3		X	X	X	X			X	X
Leading Indicators									
Orders received accuracy (realized vs. plan)	X	X	X					X	X
Number of supplier quality claims		X	X	X	X			X	X
Number of design change requests		X	X	X				X	X
Supplier delivery accuracy (to be updated)		X	X	X	X	> X %		X	X
Order acknowlegment lead time days	X	X	X	X	X	X		X	X

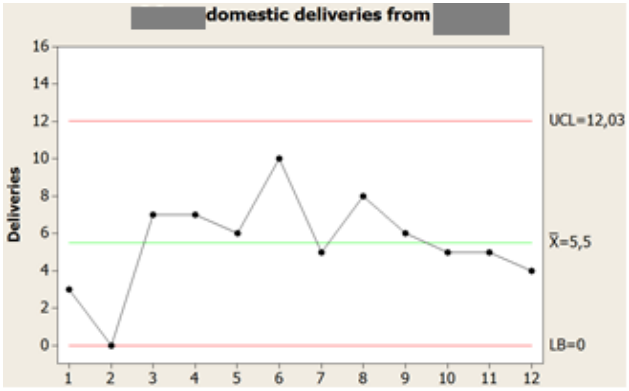
On plan or better

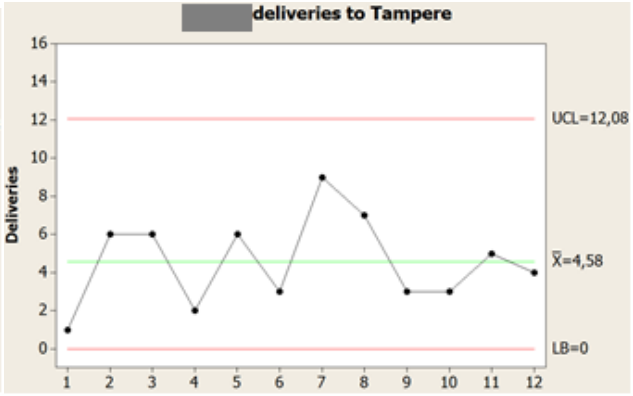
Below plan (max 20% delta)

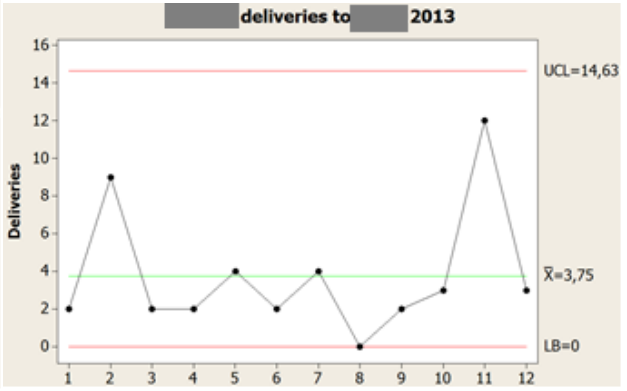
More than 20% below plan

Appendix 18. Product group Y monthly deliveries

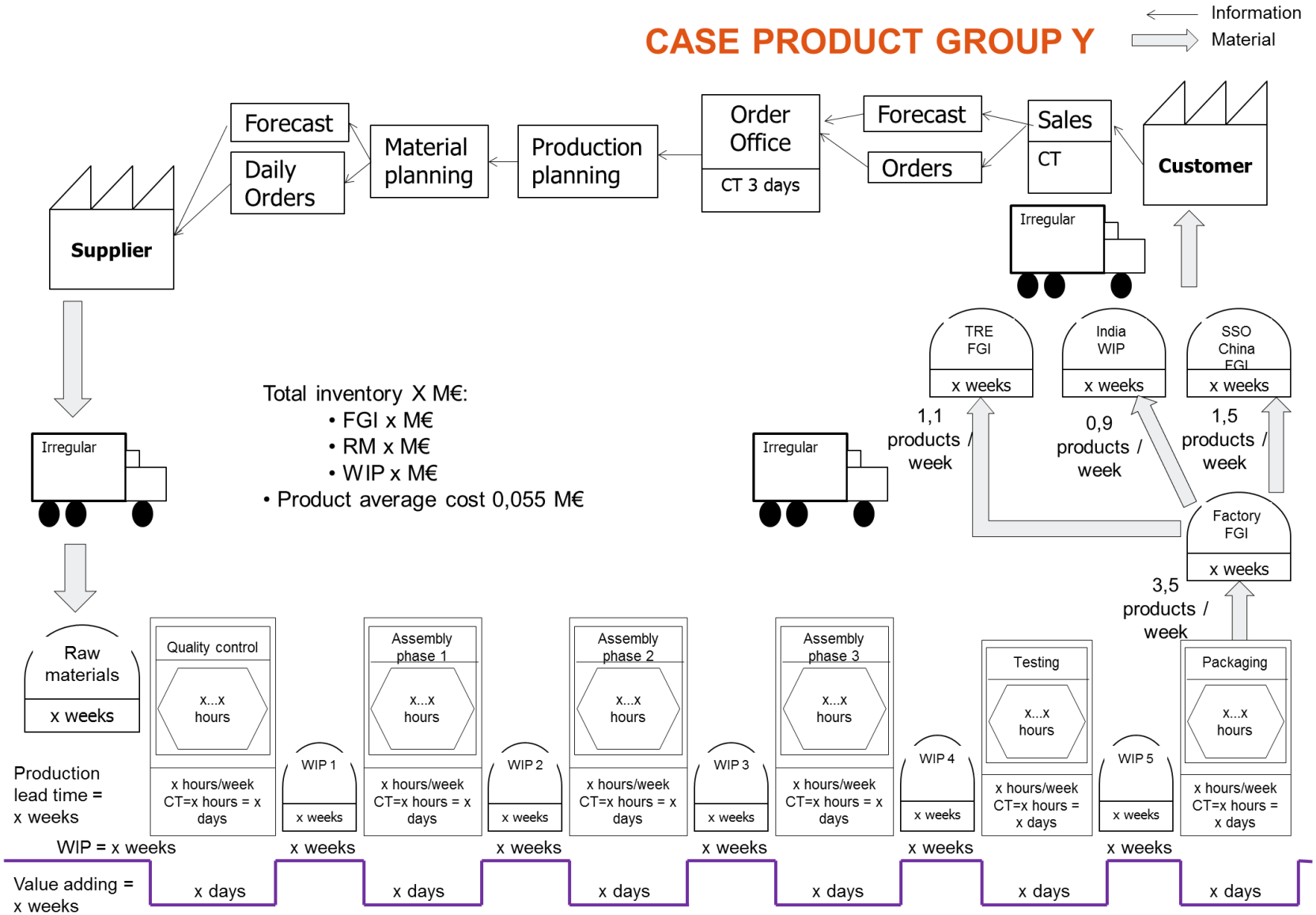








Appendix 19. Initial value stream map for product group Y



Appendix 20. Product group Y material lead time per material vs. demand (width)