TALLINN UNIVERSITY OF TECHNOLOGY
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

# LEAN APPROACH IN IMPROVING SALES AND PRODUCTION EFFICIENCY ON THE SAMPLE OF FORS MW AS

# LEAN-JUHTIMISE LÄHENEMINE MÜÜGI JA TOOTMISE EFEKTIIVSUSE PARANDAMISEKS ETTEVÕTTE FORS MW AS NÄITEL

MASTER THESIS

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Tallinn 2021

(*On the reverse side of title page*)

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**Department of Machinery**

# THESIS TASK

**Student**: Olga Komissarova, 192517 MARM

Study programme: Industrial Engineering and Management (MARM)

Supervisor(s): Associate Professor – Kristo Karjust

Consultant(s): Tony Fransson, Senior Purchasing Developer

(Fors MW AS, 6790000, tony.fransson@forsmw.com)

**Thesis topic**:

(in English) Lean approach in improving sales and production efficiency on the sample of Fors MW AS

(in Estonian) Lean-juhtimise lähenemine müügi ja tootmise efektiivsuse parandamiseks ettevõttes Fors MW AS

**Thesis main objectives**:

1. Main objective is to raise efficiency in sales and production by lean approach
2. To perform lean diagnostics and to find out where improvements are needed
3. To make practical improvement suggestions

**Thesis tasks and time schedule:**

| No | Task description | Deadline |
|---|---|---|
| 1. | To perform a detailed analysis of Fors MW current situation (production and sales operations) | 18.03.2021 |
| 2. | To get understanding of lean tools and techniques applicable, investigate success of Toyota and Scania production systems. | 15.04.2021 |
| 3. | To study lean implementation challenges. To create Lean house of Fors MW. To perform lean level diagnostics of Fors MW. | 01.05.2021 |
| 4. | To recommend appropriate lean techniques and identify problems that Fors MW have had /may have during implementation | 10.05.2021 |
| 5. | To come up with practical solutions | 15.05.2021 |

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# PREFACE

I joined Fors MW in 2006 and over the last few years I have worked in logistics, production planning, and now in the sales order handling department, also working in the supply chain. The company became not only a common workplace for me, but also gave me the inspiration to study production management.
The management of the company started a project related to lean and operational efficiency, and I am a part of that. That gave me an idea to explore the lean approach more deeply and see the possibilities for the company as well.

I would like to thank Tony Fransson, Senior Purchasing Developer, for his patience in listening to sales problems, sharing his knowledge and helping me. His work experience at Scania is of great value.

I would like to express my gratitude to my thesis supervisor, Professor Kristo Karjust, for guiding me.
Finally, I would like to thank all my work colleagues who shared information and ideas with me and were connected in one way or another with this thesis.

*Keywords: lean manufacturing, lean implementation, lean assessment, improvement*

# List of abbreviations and symbols

| | |
|---|---|
| ATO | Assemble to order |
| DOS | Days of supply |
| EOQ | Economic order quantity |
| ERP | Enterprise resource planning |
| ETA | Estimated time of arrival |
| FCA | Free Carrier (Incoterms) |
| GR | GlobalReader (software and hardware to track production devices performance) |
| ID | Identification |
| KPI | Key Performance Indicator |
| LAT | Lean assessment tool |
| MOQ | Minimum order quantity |
| OEE | Overall Equipment Efficiency |
| OTD | On time delivery |
| PDCA | Plan-do-check-act |
| R&D | Research and Development |
| SMED | Single-minute exchange of die |
| SOP | Standard operation process |
| SPS | Scania Production System |
| TPM | Total productive maintenance |
| TPS | Toyota Production System |
| TQM | Total quality management |
| VSM | Value stream mapping |
| WIP | Work in progress |
| WPS | Welding procedure specification |

# 1. INTRODUCTION

Estonia is no longer the land of cheap labour. The salary rate is relatively high compared to Central and Eastern Europe. (Eurostat, 2020)
Robotisation in Estonia is in an active stage of development, but still very far behind the Northern and Western Europe.

Estonia's manufacturing companies are mainly of medium size, they must struggle every day with the difficulties of finding competent, skilled workforce, to cope with increasing raw materials prices, to balance uncertain supplier deliveries. As a result - long delivery times, ineffective manufacturing processes, large inventories and work in progress (WIP) - a lot of money is wasted.

Another aspect is that due to customization there are always new requirements and last-minute changes at short notice by the customer, to which the company must react quickly.
Old good batch production and large safety stock of purchased parts and half-ready production waste the money and do not satisfy the customer.

Here we come to the crucial point – just as Toyota came out with lean manufacturing after the Henry Ford industrial revolution, companies today need to change themselves to become more lean to be competitive.

Many companies in Estonia are aware of lean principles and have incorporated some of the techniques into their everyday work.

The author of this master thesis has many years of work experience in Fors MW AS (in the logistics department, production planning, supply chain and order handling). Fors MW AS is a leading producer of forestry and agriculture trailers and cranes, the manufacturing plant is located in Saue.

The company has implemented some lean techniques and is willing to develop more „lean ". There are clear goals to increase the efficiency in sales and production. In the middle of the lean transformation, two main questions arise:
1. How advanced is the lean implementation?
2. Which lean techniques or processes should be focused on depending on the level of lean implementation?

The main body of the thesis consists of three parts.
In the first part, the company is briefly introduced, the current situation of the company is described, the detailed analysis of Fors MW AS sales and production processes is performed. On-time delivery is one of the key performance factors to measure customer satisfaction. The analysis of that performance together with root cause investigation will be done.

The second part is based on the literature review. First, lean and a successful lean implementation are presented theoretically using the Toyota Way and the Scania Way as examples. There are many benefits of a successful lean implementation – besides increased sales and operational efficiency, there is also improved quality, improved visual management, a safe work environment and improved employee morale. Lean techniques and potential implementation issues are also discussed in part two.

The final third part focuses on practical solutions in the context of the company. The lean house of Fors MW AS is to be created. Lean audit results to be presented. VSM (value stream mapping) current and future state for the crane production shall be shown and described. Improved sales order process shall be explained.

## 1.1 Research objectives and tasks

The purposes of this research are summarized as follows:

- The main goal is to raise efficiency in sales and production using lean approach.
- To perform lean diagnostics and find out how advanced is lean implementation in the company.
- To come up with practical improvement solutions

The company has estimated the following goals for 2025 year:

- Turnover – to be increased 25 %
- Delivery time – 4-6 weeks
- On-time delivery 90 %
- Net profit 8 %

The author has created the following tasks and schedule is shown in Table 1-1.

Table 1-1 Task schedule

| No | Task description | Deadline |
|---|---|---|
| 1. | To perform a detailed analysis of Fors MW current situation (production and sales operations) | 18.03.2021 |
| 2. | To get understanding of lean tools and techniques applicable, investigate success of Toyota and Scania production systems. | 15.04.2021 |
| 3. | To study lean implementation challenges. To create Lean house of Fors MW. To perform lean level diagnostics of Fors MW. | 01.05.2021 |
| 4. | To recommend appropriate lean techniques, calculate cost and identify benefits | 10.05.2021 |
| 5. | To come up with practical solutions | 15.05.2021 |

## 1.2 Research methodology

The research strategy of the study is a case study research method. The method involves a detailed qualitative and quantitative analysis within a case. (Rashid et al., 2019)

The author has followed the phases, presented in the table 1-2.

Table 1-2 Research methodology

| Research phase | Method | Result |
|---|---|---|
| Literature study | Mixed research technics | Lean, lean house, lean production system, lean implementation theoretical structure. |
| Data collection | Documents and records; observation; interview | The information, needed for the case study, is collected |
| Data analysis and assessment | Qualitative and quantitative analysis | Company process description using Bizagi program, Lean house creation, lean audit, VSM (value stream map) future and current state, new sales order process |

# 2. COMPANY INTRODUCTION AND OPERATION ANALYSIS

"Make everything as simple as possible, but not simpler." Albert Einstein (paraphrased), 1933 (Leybourn, 2013)

This first chapter will give brief introduction of the company and general processes. Significant changes, started from the 2016 year, will be introduced. The author will make analysis of current situation of the company in the second chapter.

## 2.1 Fors MW AS brief introduction

Fors MW focuses on development and sales in three business areas: agriculture, construction, and forestry. Products are marketed and sold worldwide. Fors MW is the company behind the European market leading products FARMA lumber trailers with crane, tractor processors and BIGAB hook lift and dump trailers.

Fors MW production and most of the assembly is based in Estonia. The company is Swedish owned, established in 1992 and one of the oldest companies to be established by foreigners in Estonia. AS Fors MW´s headquarter is placed in Saue, Estonia 15km from the main capital Tallinn (Figure 1). There are around 250 dealers in over 30 countries worldwide. Activities within the company should be characterized by the desire to continuously develop personal skills as well as company.

Figure 1 Fors MW AS plant in Saue (*FORS MW*, 2021)

Figure 2 BIGAB hooklift trailer (*Hook Lift Trailer Bigab*, 2021)


Figure 3 FARMA trailer with crane (*FARMA Fors MW*, 2021)

Figure 2 and 3 demonstrates the main brand products.

### 2.1.1 Organizational structure

Company has functional organisation structure. Author has created the organiszational chart (Figure 4).

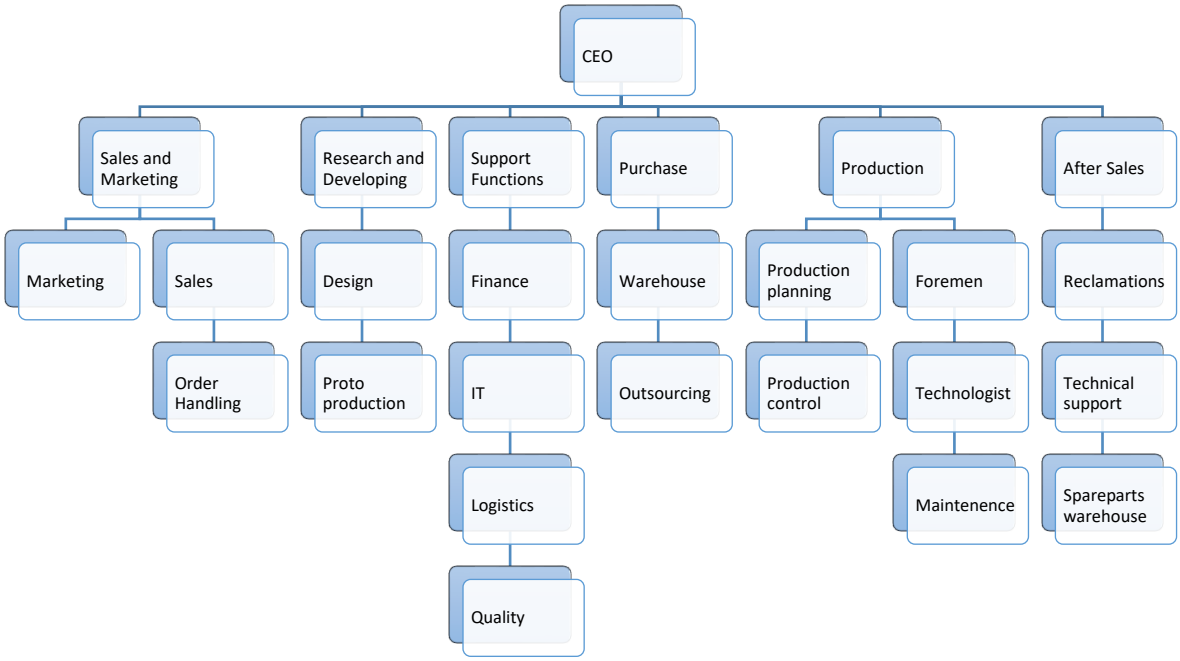


Figure 4 Company structure

### 2.1.2 General process and sales process

AS FORS MW's business concept is to develop, manufacture and sell professional high quality customized products, at a competitive price, to as wide a market as possible in the areas of agriculture, forestry, and construction.

The author has used the Bizagi program to illustrate the general processes (Figure 5).

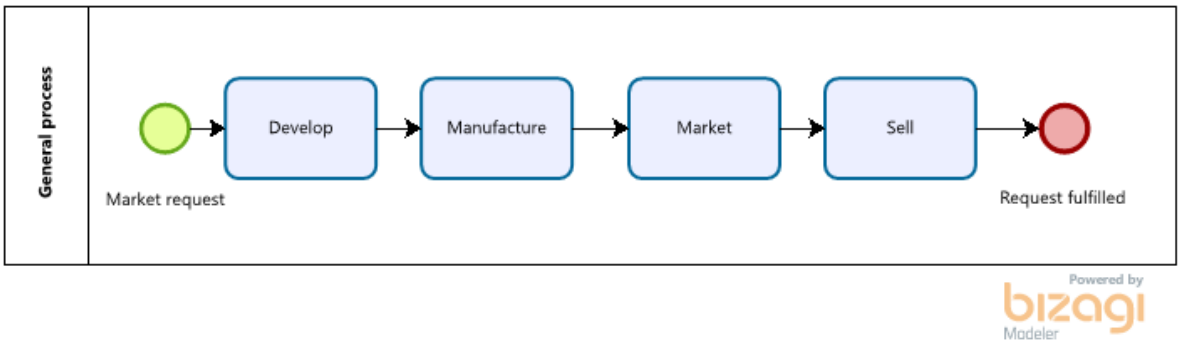


Figure 5 General process

The importance of development is emphasised. The company has its own brand names (Farma and Bigab), what gained customers positive feedback over the world. The brands are in constant development and provide the customers with the improved versions and new solutions. The customers actively participate in the tests, buy and try the prototypes, by giving feedback. R&D (Research and Development department) is one of the largest in the company.

In the simplified version (Figure 6) the general sales process is logical – the company receives a customer order, the purchasing department takes care of the raw materials, the production department manufactures, the logistics department ships, the finance department issues invoices.

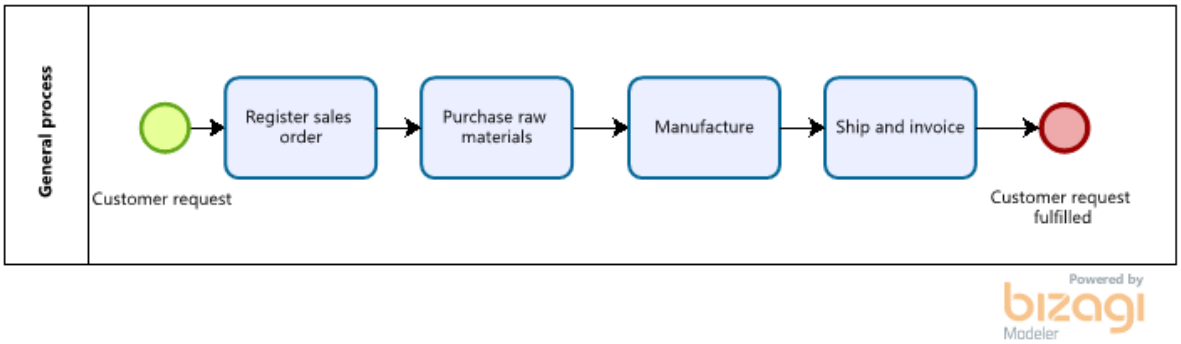


Figure 6 General sales process

However, this general procedure only works for 70 % of the parts sold.
Due to customization or special customer request, 30 % of the sales orders need engagement of R&D department from the beginning.

The general sales process of the company work is shown in the following scheme (Figure 7).

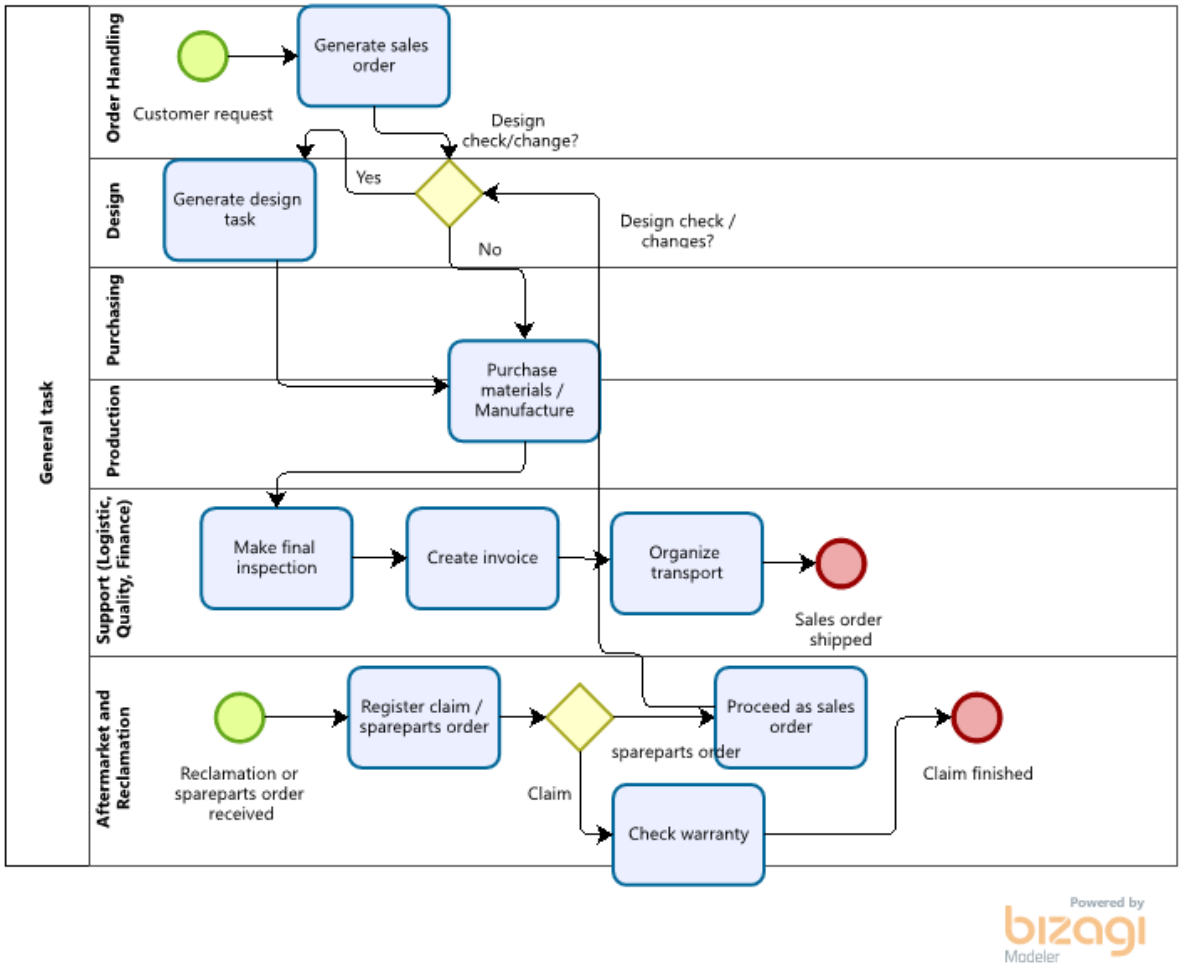


Figure 7 Detailed sales process

To provide the customer with highly customized product, the design is integrated into the process from the very beginning. In the case of a special request, the Order handling department creates design task, and the sales order will be confirmed to the customer after R%D department verification.

Quality department together with Spareparts and reclamation departments cooperates tightly with R&D department with the aim to solve the customer claims, to find root cause and implement needed changes for improvement.

The company has no ISO certificate, but working quality system based on the ISO principles.

### 2.1.3 Production process

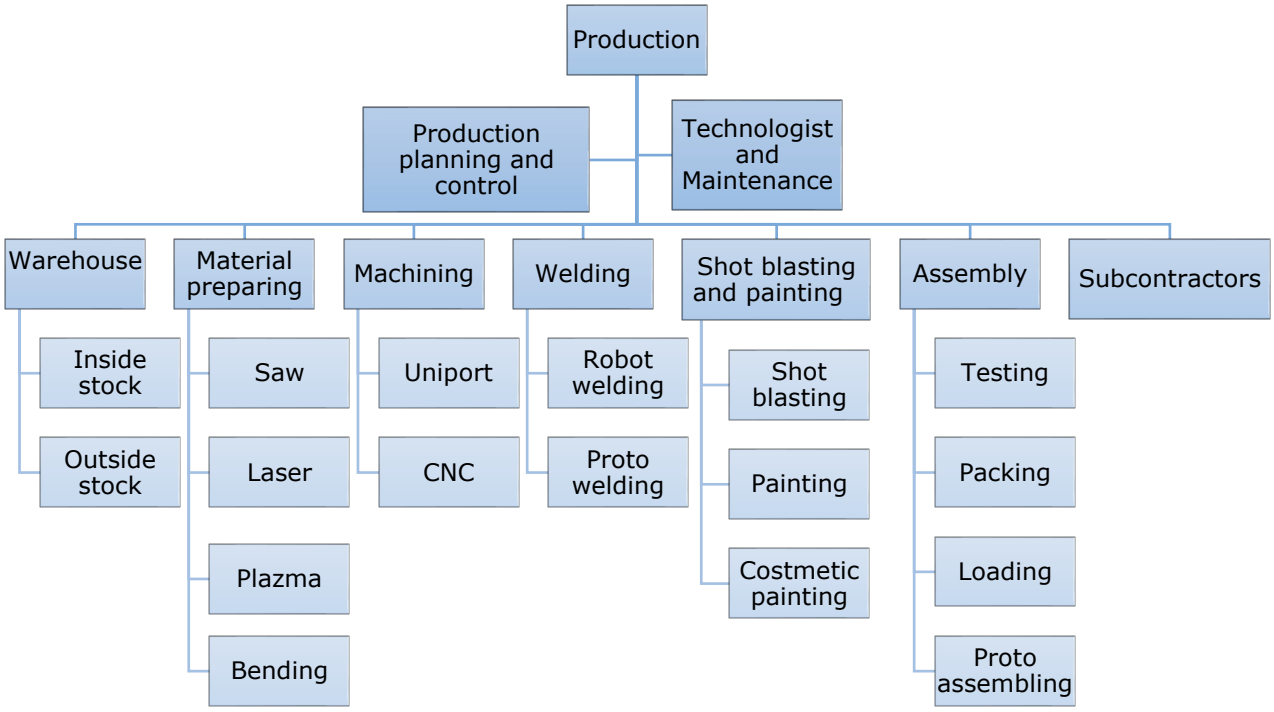


Figure 8 Production department chart

The production department is the largest department in the company, employing 75% of the company's personnel.

In general, the production department can be divided into main 2 parts – the so-called big production (cutting, machining, welding and painting) and small production (assembly). The big production is mostly batch production, the small production is make to order and is planned exactly according to the customer orders.

### 2.1.4 Company current situation

From the beginning, the company was led by its founder Leif Fors, who was fully committed to the company - from designing, managing the production, to testing of the products on his own farm. The company evolved and grew. Sadly, Leif Fors passed away in 2015.

As of 2016, Fors MW has hired a new production manager, and under his initiative many projects have been started or continued with new energy.

The following list is done according to start date.

1. **Timing** (norming, part of standardisation) – as many new products were developed, due to changes in materials and technology, the situation showed that many preparations did not have correct timing information. The biggest department affected was welding. The timing (norming) was performed as simple time counting, analyses (reported time versus standard time) and subsequent preparation changes.

2. **WPS project**

The quality of the welding work is of great importance to the company because of the specifics of the work (welding is one of the core departments).

A Welding Procedure Specification, or WPS, is a document that serves as a guide for the effective creation of a weld that meets all applicable code requirements and production standards. The idea of WPS is as a recipe for welders.

WPS project was implemented within 40 weeks.

3. **6S system**

In 2016 6s implementation started. 6S is 5S but with an extra S for safety. (IPMA, 2018)

Implementation started from the biggest department (welding) with the help of consultant. After successful pilot project in welding, it was repeated in the other departments during 2016 – 2019 years.

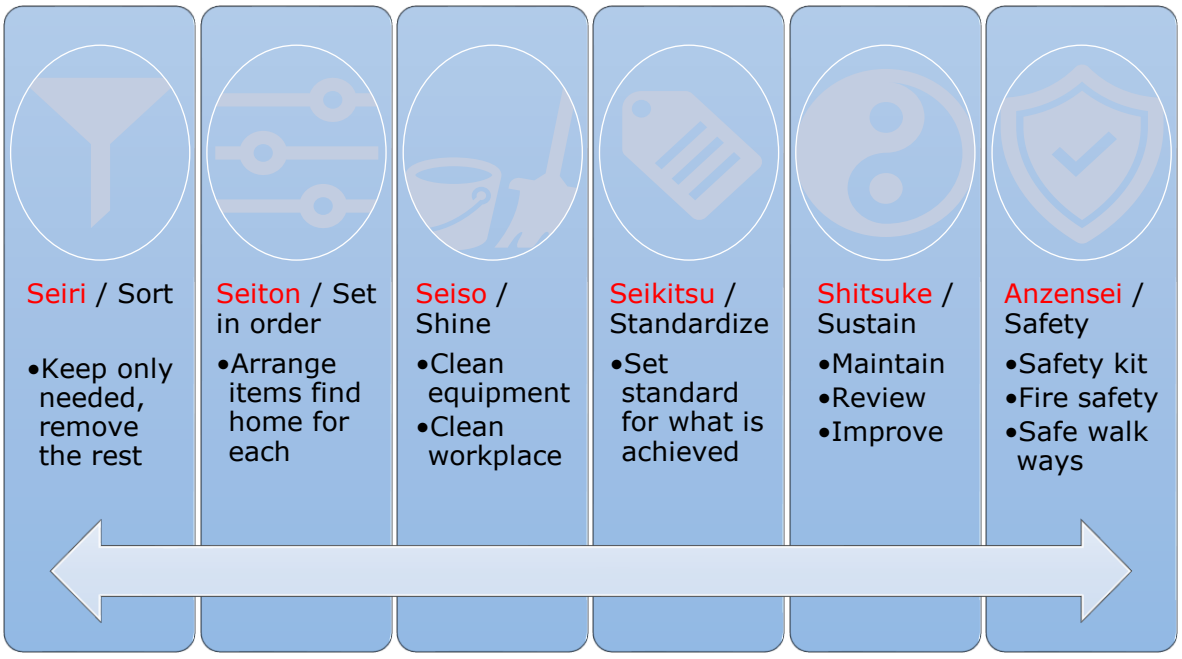


Figure 9 6S Lean (5S+Safety)

5S system alone, is not a core lean technique. 5S itself does not lead to better quality or lower costs; but it is a powerful tool in the workplace to make the problem visual and by that support continuous improvements. (Liker, 2004)

4.**Identification and revision management**

Since the nomenclature in the company is about 10 000 parts, this number is multiplied by the revision number. A very serious problem - as parts also had to be changed due to design changes in the product BOM. There were many unidentified /unknown parts in stock before.

As a result, ID requirements were forwarded to all suppliers, internally ID requirements were identified, rejected and scrap flow reported.

5. **Planning management**

Planning is the heart of every production. The company's production planning is in ERP program Monitor. The planning process had to be overviewed (major production planning parameters determination: MOQ, EOQ, LT, MIN/ MAX stock levels etc.), and Monitor activities were added to have detailed plan in real time. Working terminals were actively commissioned, which enabled tracking of all manufacturing orders in real time. Weekly capacity analysis of all manufacturing departments was started.

6. **TPM (Total Productive Maintenance) project**

TPM is designed to disseminate the responsibility for maintenance and machine performance, improving employee engagement and teamwork within management, engineering, maintenance, and operations.

According to Robert Williamson, TPM is the original equipment-improvement side of the Toyota Production system. (Moore, 2007)

TPM is one of the important lean techniques, especially for the manufacturing company. TPM is an equipment improvement strategy –organization-wide, data-based, focusing on elimination of the major equipment-related losses and involving everybody who contributes to a problem. (R. Williamson, 2016)

7. **TPM jigs**

As the number of jigs in the company is more than 400, to keep their performance on high level, it was a clear need for TMP jigs plan.

8. **Final inspection in assembly**

All finished products are subjected to final inspection before they are shipped to the customers. It was a part of quality system implementation.

9. **Measuring points**

To check the quality of raw materials (such as metal sheets, bars) and welding parts, the manual needed to be created. Again, it is a part quality implementation.

10. **New machining centre**

The company has faced many problems with CNC and other machining tools. Outdated equipment, problems with spareparts, operators and many quality issues. Decision was to set up a new machining centre from Unisign (Uniport6000).

11. **GlobalReader (GR) Real-time IOT monitoring**

Real-time overview of production equipment status, efficiency and work. GR has been installed.('GlobalReader', 2015)

Production device monitoring answers the most important questions about device working performance, such as working time, downtime, OEE (Overall equipment efficiency). Integration with the quality department was set up – in case of a quality problem the operators register it in GlobalReader, which sends message directly to the concerned people.

12. **New bonus system idea for the workers**

It must be more individual and depend on KPI performance.

13. **New welding robots** were taken in use.

14. **New bending machines** were taken in use.

## 2.1.5 Company projects status

The situation by 2021 with projects status is showed in Table 2-1.

Table 2-1 Project status 2021

| SET | PROJECT NAME | STATUS | PROGRESS |
|---|---|---|---|
| 1 | Norming at welding department | Finished | |
| 2 | WPS PILOT implementation | Finished | |
| 3 | 6S implementation | Finished | |
| 4 | Identification & Revision management | ON TRACK | 85% completed |
| 5 | TPM implementation | Finished | |
| 6 | Welding jigs TPM implementation | Finished | Storage system completed; Maintenance subject resource allocated |
| 7 | Planning system implementation | Finished | 30% Completed, Structural (BOM/ Routing) changes in progress, safety lead time and safety stock analysis to be done |
| 8 | Final Inspection | Finished | |
| 9 | Measuring points implementation at operator level | ON HOLD | Some measuring points tested in Monitor. |
| 10 | Machining centre implementation | On track | |
| 11 | Global reader OEE monitoring tool installation | Finished | |
| 12 | KPI new bonus program implementation | Finished | New bonus system launched January 2021. |
| 13 | New welding robot preparations | Finished | |
| 14 | New bending machines preparations | Finished | |

## 2.2 Operation analysis

To maintain competitive advantage, the company must find ways to improve on the everyday base. One possibility is to increase efficiency.
There are four way to do this:

- achieve more results with the same resources
- achieve significant results with little investment
- achieve the same results with fewer resources
- to achieve slightly less by significantly reducing

Before choosing the option, the analysis of efficiency must be carried out.

The author has done an analysis of sales and production operations. Both depend on each other, misunderstandings between these two departments multiply the probability of errors. The business performance indicators, such as ROI (return on investment), ROS (return on sales) and sales are not calculated.

In this chapter, author concentrates on operational performances, such as delivery reliability with root cause analysis, labour productivity, inventory turnover, as there is a positive link between lean production and operational excellence.

### 2.2.1 Delivery reliability

Meeting customer's expectations and delivery requirements is a priority for the business. OTD (On-Time Delivery) is a metric used to access the ability of a company to fulfil the shipment within the period or promised delivery time. (Johnston, 2013)
Poor OTD performance is a clear indicator of poor production efficiency and supply chain procedures but could also be the result of inflated sales promises and poor forecasting.

Table 2.2 shows the calculation of OTD in a simple way - number of shipments (rows), delivered on time to the customer, relative to the total number of order rows shipped. 1–3 day delay and 2 days earlier delivery were counted as on time, because they did not affect ETA (estimated time of arrival). The author has taken rows, not orders, as some orders contain many shipments.

Table 2-2 Tracking 2-month-loading plan (October and November 2020)

| Week | 2020 year | Sales orders, rows | Delivery date correct | 2 + days earlier | 3+ days delay | OTD (+2-3 days) |
|---|---|---|---|---|---|---|
| week 41 | 05.10-11.10 | 132 | 86 | 3 | 43 | 67% |
| week 42 | 12.10-18.10 | 156 | 62 | 3 | 91 | 42% |
| week 43 | 19.10-25.10 | 268 | 141 | 2 | 125 | 53% |
| week 44 | 26.10-01.11 | 178 | 112 | 2 | 64 | 64% |
| week 45 | 02.11-08.11 | 247 | 161 | 5 | 81 | 67% |
| week 46 | 09.11-15.11 | 113 | 85 | 4 | 24 | 79% |
| week 47 | 16.11-22.11 | 96 | 67 | 1 | 28 | 71% |
| week 48 | 23.11-30.11 | 252 | 172 | 4 | 76 | 70% |

As it shown in Table 2-2, OTD statistically is low, average is 64 % per week, far from estimated 90 %.

Going deeper, analyse of the sales orders showed many different reasons for delay. The first analyse was made by investigating sales orders status, to get overview of the main reasons of delay.

The delay reasons can be grouped in the following sectors (Figure 10): sales and order handling (customer and order handling problems), purchase (supply-chain), production, logistics and design.

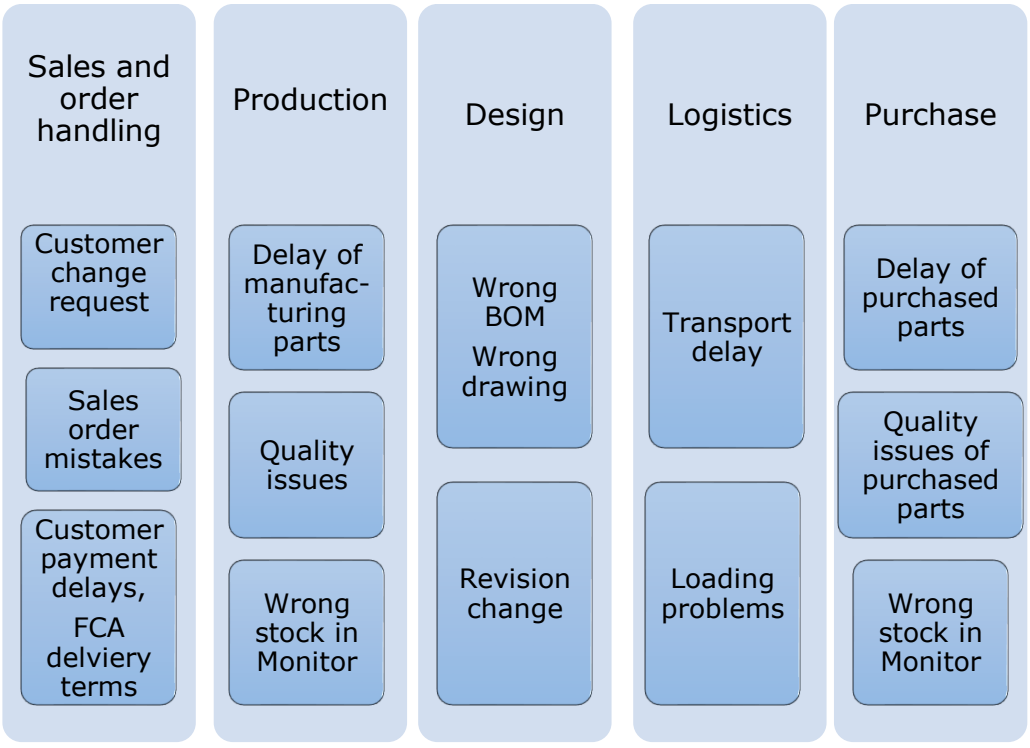


Figure 10 Main delay problems

Next general division in Figure 11 shows the share of inhouse problems (solution possible inside), and outside problems (solution with collaboration of partners), based on analysis of 2- month-deliveries. Sales orders delays are mostly caused by manufacturing parts delay or purchasing details delay. By splitting the problems, the author wanted to show, that 62 % of the delays have happened inside the company, their elimination can start immediately.

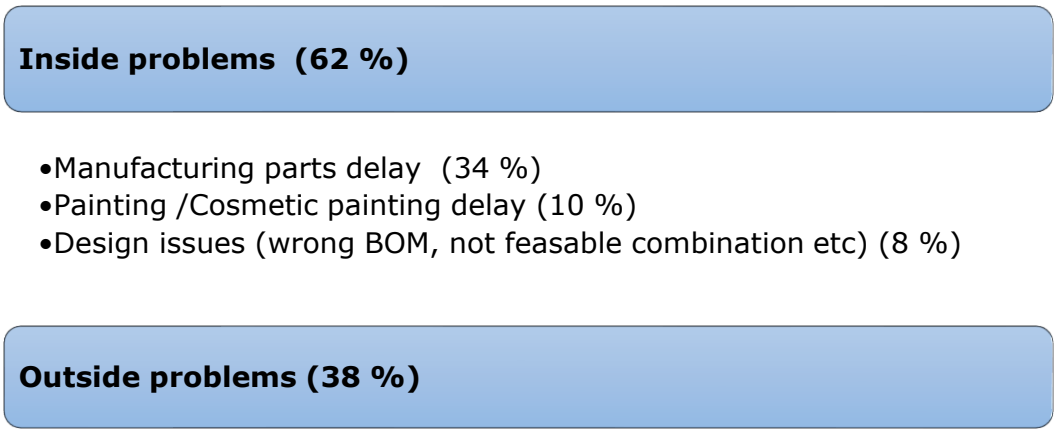


Figure 11 Problems division

To get better understanding of cause-and-effect relationship, root cause analysis should be used.

The author used the 5-Whys method to investigate the root cause of errors in order handling. The 5-Whys root cause analysis is a famous Toyota problem-solving method.(Liker, 2004)
One of the typical examples is that orders are becoming more complicated due to customization. The author has used the 5-Whys method to show in Figure 12 that in the case, where a customer order has been confirmed for an unfeasible combination of parts, a properly prepared and carefully checked price list can prevent the error.

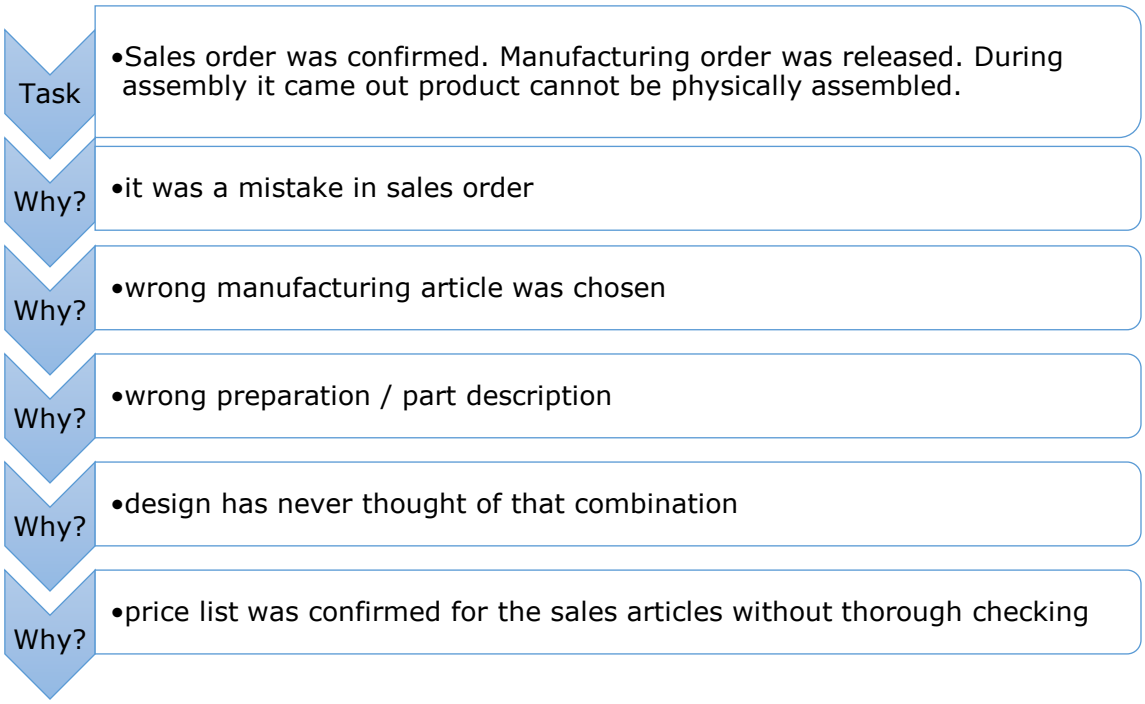


Figure 12 5-Whys method

However, the author is aware of criticisms of the 5-Whys method, such as asking the wrong questions and stopping at symptoms.(Card, 2016)
Digging deeper, it is likely that the real source of the problem is not only the price list with multiple errors, but also too few personnel in the R&D department, or unqualified product engineers, leading to insufficient engineer's university education level.

To see the whole field of problems, other methods must be used. The Ishikawa diagram was invented by Kaoru Ishikawa, who pioneered quality management techniques in Japan in the 1960s. The 5 Ms Fishbone (Ishikawa diagram) was actively used in TPS (Toyota Production System).(Luca, 2016)

6M of fishbone diagram (Figure 13) stand for method (production operations, rules), milieu (mother nature, safety), materials, machines (equipment), manpower and measurement (inspection).

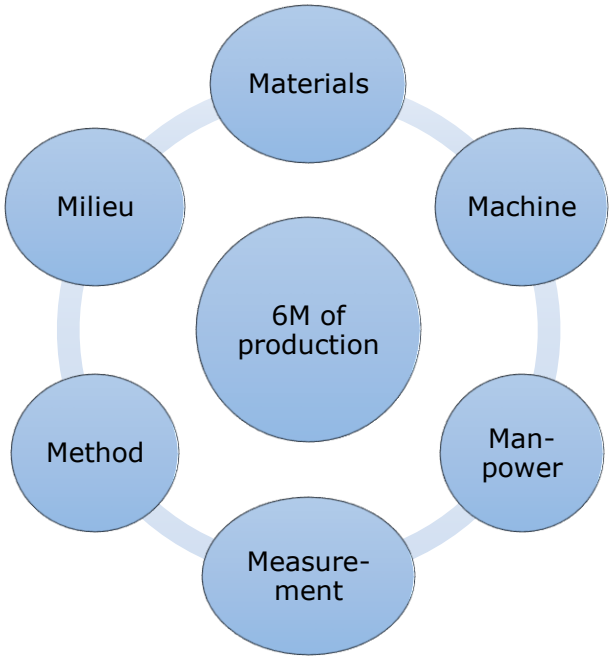


Figure 13 The 6M of production (Luca, 2016)

Using the fishbone diagram (Figure 14), the author can show the root causes of the problem in all 6 categories. The solution steps should be discussed and implemented separately. To archive desired 90 % OTD, the improvements are needed in all 6 categories. One of the solutions is new sale order process, what will be explained in the last part of the thesis.

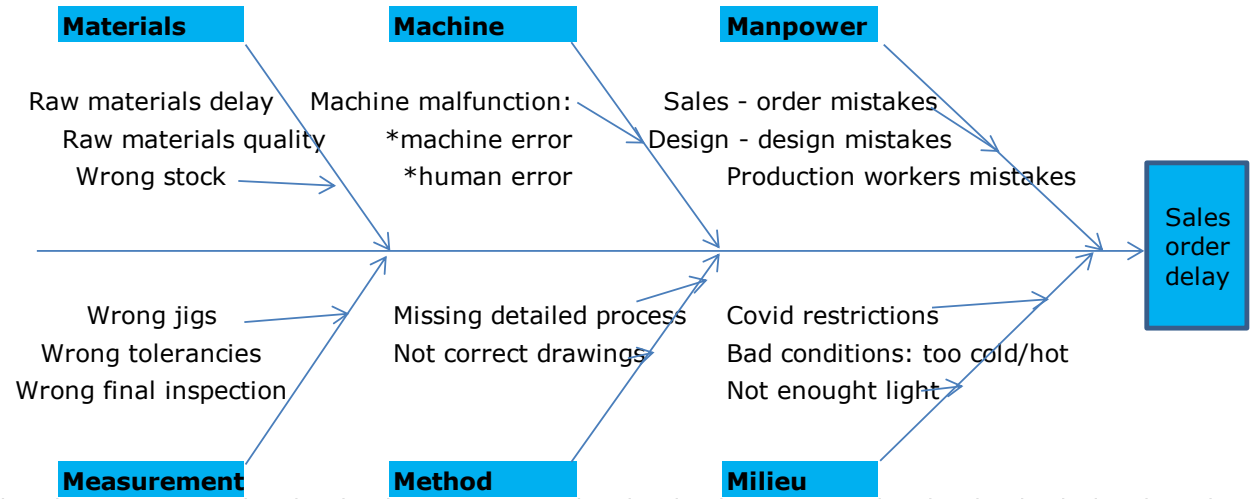


Figure 14 Ishikawa diagram of sales order delay

### 2.2.2 OEE and productivity

Production controller of the company is responsible for the production analysis. Excellent set of major characteristics is calculated (such as OEE, productivity per department / equipment / operator; supply chain analysis – stock, WIP, etc; working hours statistics etc) on the week and monthly bases.

Author has checked ready-made OEE and productivity analysis and came out with important notes.

Table 2-3 OEE June-December 2020

| Department | June'20 | July'20 | Aug'20 | Sep'20 | Oct'20 | Nov'20 | Dec'20 |
|---|---|---|---|---|---|---|---|
| ASSEMBLING | 97% | 94% | 98% | 99% | 99% | 99% | 99% |
| WELDING | 81% | 77% | 77% | 76% | 73% | 72% | 74% |
| PREPARATIONS | 59% | 50% | 63% | 67% | 64% | 68% | 71% |
| MACHINING | 45% | 47% | 51% | 59% | 61% | 52% | 62% |
| PAINTING | 77% | 72% | 88% | 87% | 78% | 85% | 81% |

GR calculates OEE performance and, as shown in Table 2-3, assembling department has the highest rate of 99 %.
However, in practise, assemblers sign in in the morning when they start working and sign out at the end of the working day. The work of the assemblers is manual. What happened during working hours- do they have to wait for order documents, or materials, or are there quality problems? Did the telpher crane work properly? GR does not show that in the assembling department.

The search for productivity based on Monitor, as shown in Table 2-4, yields different result.
If GR measured working performance (with no relation to the order itself), analysis based on Monitor data examines orders what were physically completed.
The logic of the calculation is the following: the actual order time is divided by the planned/scheduled order time. How accurate this result, is depends on how correctly the order was written off; most importantly, how accurate the planned time is in preparation.
Behind large numbers, such as more than 100 %, could be outdated preparation with incorrect timing information, and conversely, behind small number could be invisible real improvement.

Table 2-4 Monitor productivity June-December 2020

| Department | June'20 | July'20 | Aug'20 | Sep'20 | Oct'20 | Nov'20 | Dec'20 |
|---|---|---|---|---|---|---|---|
| ASSEMBLING | 61% | 72% | 64% | 107% | 112% | 98% | 103% |
| WELDING | 74% | 80% | 84% | 86% | 85% | 88% | 80% |
| PREPARATIONS | 96% | 126% | 152% | 137% | 128% | 141% | 134% |
| MACHINING | 54% | 61% | 67% | 70% | 80% | 78% | 88% |
| PAINTING | - | - | - | - | - | - | - |

The OEE and productivity analysis (based on Monitor and GR data) is available per operator and per working centre, but author does not think they show the real situation in the company. Yes, machine-based statistics is more reliable in comparison with manual operator statistics.

The author main concern relates to the fact, that neither GR no Monitor analysis considers all registered and planned orders, but only what orders have been fulfilled. Conformance to plan analysis of all planned /scheduled orders versus fulfilled orders; orders fulfilled on-time versus late/early competed orders should be added to the week / monthly statistics to capture actual performance.

### 2.2.3 Supply chain analysis

It is important to have an overview of the purchased parts, WIP and half-ready parts stock level. The author shows in Table 2-5 the tendency of changing of stock level in the years 2018-2021. If to take the first year as 100 %, then 110 % in 2021 year means the company has increased the stock level by 10 %. Table shows the biggest increase of 5 % in WIP products. It is the clear point and need for improvement.

Table 2-5 Inventory level 2018-2021

| | January 2018 | January 2019 | January 2020 | January 2021 |
|---|---|---|---|---|
| **WIP** | 6% | 8% | 6% | 11% |
| **Half ready** | 24% | 41% | 32% | 26% |
| **Purchased materials** | 70% | 80% | 78% | 74% |
| | | | | |
| **SUM** | **100%** | **129%** | **115%** | **110%** |

The author has calculated DOS (days of supply), dividing cost of average inventory to average sold per day. The result in the company is 65 days. Inventory turnover ratio

(net sales divided by inventory) is 5,6. A good turnover inventory ratio is between 5 and 10, so in general the situation can be classified as good. (Industry Ratios, 2020).

However, there are many aspects to consider – some parts are in phasing out or obsolete status, some are dead stock. If to have such articles under control and to deal with them on continuous base, the company will have a better cash flow as the money invested in the stock will generate better returns. (CSCMP et al., 2014)

### 2.2.4 Customer claims analysis

The author looks at quality in the eyes of the customer. The tendency of claims in amount and cost is presented in the table 2-6. The data of 2018 year was taken as 100 %. 2019 year has shown increase in number of claims, but the costs went down. 2020 year was with lower claim number and total cost, what is positive trend.

Table 2-6 Claims 2018-2020

| **Year** | **2018** | **2019** | **2020** |
|---|---|---|---|
| Claim number | 100% | 113% | 73% |
| Claim total cost | 100% | 88% | 71% |

# 3. LEAN AS PHILOSOPHY

In this part, the author introduces the lean philosophy and the lean main elements and concepts, based on literature review. Author will investigate success of Toyota and Scania production systems. The second par will show lean implementation process and analyses possible problems.

## 3.1 History of lean and the ways of Toyota and Scania

Roots of lean are going deeply into the XIX century. Eli Whitney is the first to be mentioned. Eli Whitney is an American inventor and mechanical engineer, most famous for developing the concept of mass production of interchangeable parts.

There are open debates about different approach in "lean" and "taylorism" but let take taylorism as lean's ancestor. Frederick Winslow Taylor is known as the Father of Scientific Management and workplace efficiency. Taylor believed that production managers are responsible to determine the best way for the worker to do their job, and decide what tools and training are needed (Selimović I, Markič m, 2020).
F. W. Taylor explained his process of using scientific studies to analyse, optimize and standardize workflow in his book "The Principles of Scientific Management" in 1911 y.

When F. W. Taylor prioritized reducing process times, Frank Bunker Gilbreth and his wife Lillian Moller, in contrast, wanted to make processes more efficient by reducing the motions involved.

The history of lean truly begins with Ford and his automobile manufacturing company in the beginning of XX century. Henry Ford was the world's first systematic lean thinker. Mass production was developed by Ford - the manufactured automobiles were of standard design and in large quantities, which made the Ford system highly efficient, delivering a product with low cost.

Main idea of the Ford system is the standardized product, which lead to the standard processes. The H. Fords ideas are described in the book "Today and Tomorrow" (H. Ford, 1926). Every worker had his own duty and performed only small specific part of the work. Moving assembly line made it possible to manufacture in the way Ford expects, like workers had to adapt to the speed of the conveyer. Ford used mass production to manufacture and assemble the components of its vehicles in minutes

rather than hours or days. Unlike handcrafted manufacturing, mass production provided components that fit together precisely and were interchangeable. Based on such successful process, the Ford Motor Company managed to produce in the years 1908-1927 over 15 million cars. During the World War II, the U.S. military has taken in Ford's mass production system.

Toyoda Automatic Loom Works was founded by Sakichi Toyoda in 1926 in Japan.
After World War II, Japan faced many problems with shortage of material, human and finance resources. There were few customers with little money. That was obvious that limited production of different models cannot be assembled by Ford system – Toyota did not have big inventories and did not have big orders of the same type. Using original Ford's idea of continuous production process, Toyota has developed new system now known as Toyota Production System. (Liker, 2004)
TPS was based on two main concepts: jidoka - the equipment stops immediately when a problem occurs; and just-in-time – each process produces exactly what and when is needed by the next process in a continuous flow.
TPS is a powerful philosophy with great development.

The term "Lean" was coined in 1988 by John Krafcik, and defined in 1996 by James Womack and Daniel Jones to consist of five key principles: "Precisely specify value by specific product, identify the value stream for each product, make value flow without interruptions, let customer pull value from the producer, and pursue perfection." (J. Womack & Jones, 1996)

The book "The Machine That Changed the World" defines lean as "shortening lead time by elimination waste in each step of a process leads to the best quality and lowest cost, while improving safety and morale" (Wormack et al, 1990)

### 3.1.1 Main elements of lean and concepts

Lean understanding is based on simple formula (Santos et al., 2006):

*Price = cost + profit*

If the cost increases, the only possibility to have the same profit is to raise the price. However, if to look at the formula from other point of view, as

*Profit = price – cost*

if the price is fixed in the market, the only possibility to maintain the profit is to reduce the costs.

Lean philosophy is based on customer value. The core idea is to maximize customer value while minimizing waste. Simply, lean means creating more value for customers with fewer resources. (Womack, Jones 1996)

The ultimate goal is to provide ideal value to the customer through a flawless value creation process that has zero waste.

There are several key lean manufacturing principles that need to be understood in order to implement lean. The seven lean principles, shown in Figure 15, are of major importance. (Poppendieck & Poppendieck, 2003)

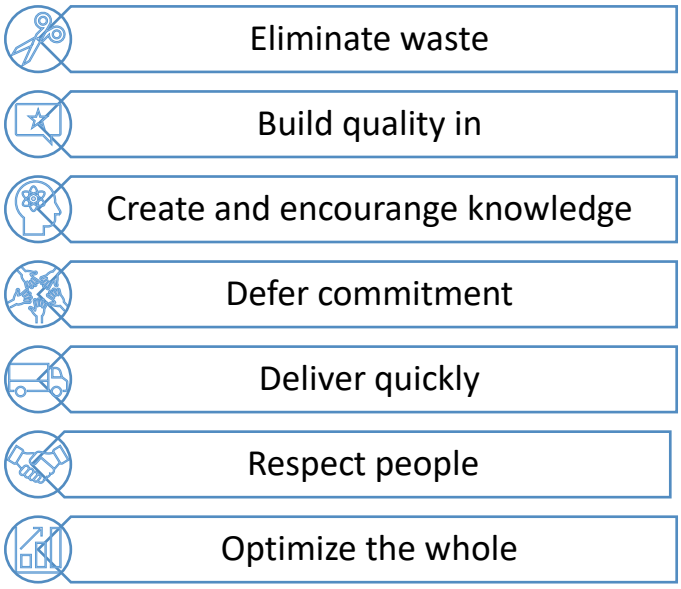


Figure 15 7 lean principles (Poppendieck & Poppendieck, 2003)

3 main enemies of lean are Muda (waste), Muri (overburden) and Mura (unevenness) (Liker, 2004).

There are 8 types of waste. The original seven wastes (Muda) were developed by Taiichi Ohno as part of the TPS. The seven wastes are Transportation, Inventory, Motion, Waiting, Overproduction, Overprocessing and Defects. The 8th waste of unused talent or skills of workers was introduced in the 1990s when TPS was adopted in the Western world.(Skhmot, 2018)


Figure 16 8 types of waste (*The 8 Wastes of Lean*, 2021)

### 3.1.2 The Toyota Way

The Toyota Way defines the fundamental valued and business methods all the workers should apply in every aspect of their work.
The Toyota Way is built on two pillars: continuous improvement, based on challenge, kaizen and Genchi Genbutsu concepts and Respect for people (respect and teamwork).

Figure 17 demonstrates the House of lean, what was created by Toyota from their lean production system. (Liker, 2004)

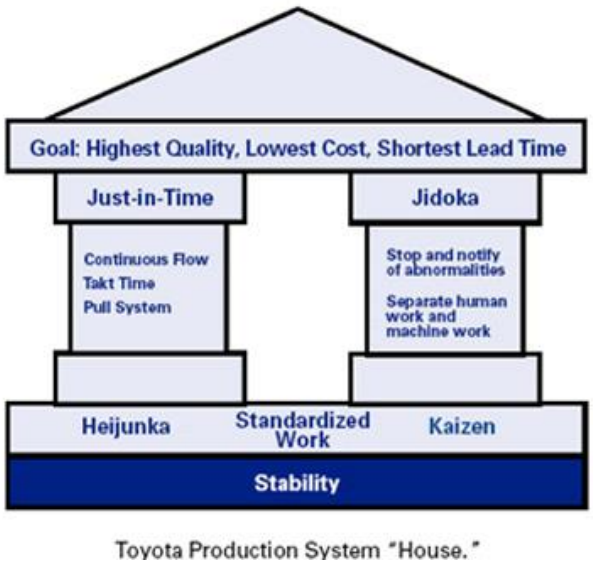


Figure 17 Toyota lean house (Lean Enterprise Institute, 2021)

**14 principles**, described in the book "*The Toyota Way: Second edition. 14 Management Principles from the World's Greatest Manufacturer*".
Principle 1: Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.
Principle 2: Create continuous process flow to bring problems to the surface.
Principle 3: Use "Pull" system to avoid overproduction.
Principle 4: Level out the workload (heijunka). ("Work like a tortoise, not the hare")
Principle 5: Build a culture of stopping to fix problems, to get quality right at the first time.
Principle 6: Standardized tasks are the foundation for continuous improvements and employee empowerment.
Principle 7: Use Visual Control, so no problems are hidden.
Principle 8: Use only reliable, thoroughly tested technology that serves your people and process.
Principle 9: Grow leaders who thoroughly understand the work, live philosophy, and teach it to others.
Principle 10: Develop exceptional people and teams who follow your company's philosophy.
Principle 11: Respect your extended network of partners and suppliers by challenging them and helping them improve.
Principle 12: Go to Gemba and see for yourself to thoroughly understand the situation (Genchi Genbutsu).
Principle 13: Make decision slowly by consensus (use cross-functional teams), thoroughly considering all options; implement decisions rapidly.
Principle 14: Become a learning organization through relentless reflection (hansei) and continuous improvements (Kaizen).

Figure 18 illustrated TPS process, what starts and ends with the customer. Customer demand reaches the company through dealer, the product order is created, then production plan is released, the heijunka sequence plan is adopted, body and various parts are produced, painted and assembled, and the ready order is shipped out.
The kanban system is central to the just-in-time process (body process and assembly), providing and automatic, real-time method to replenish parts in time.

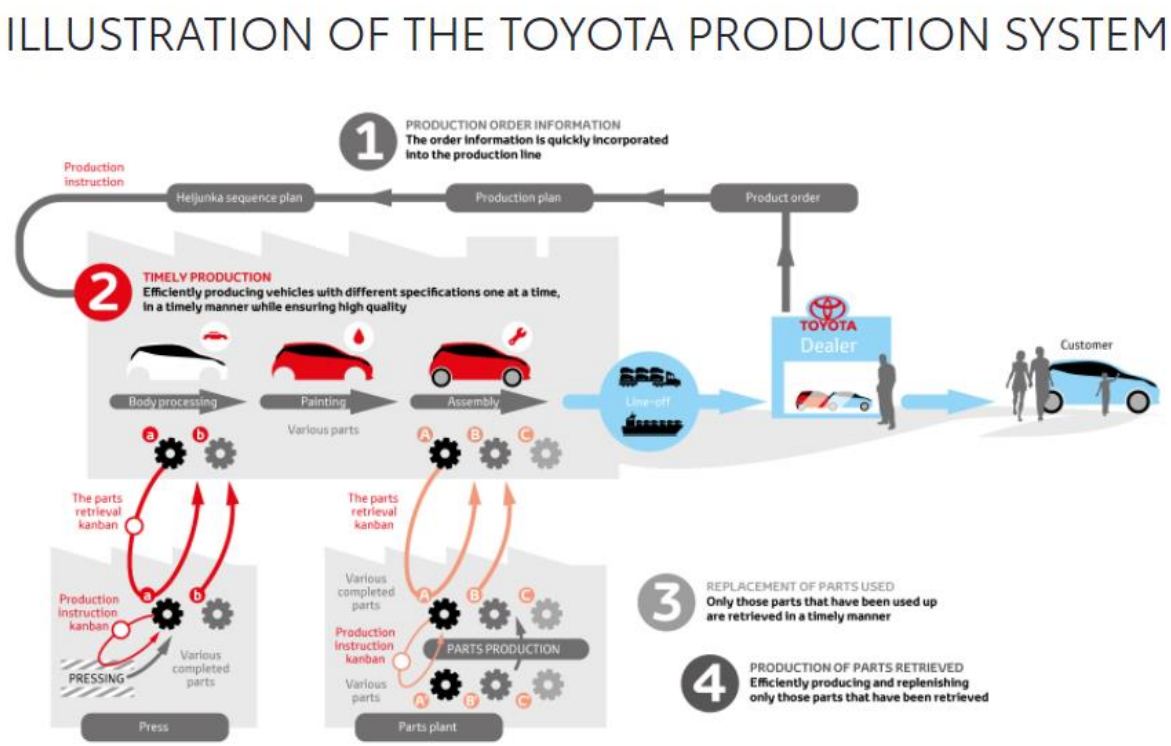


Figure 18 Illustration of TPS (*Toyota Production System - Maximising Production Efficiency*, 2021)

### 3.1.3 The Scania Way

One the successful lean implementations can be studied on the sample of Scania Production System (SPS) by Swedish company Scania.

Scania is a world-leading provider of transport solutions, including trucks and buses for heavy transport applications combined with an extensive product-related service offering. Scania offers vehicle financing, insurance, and rental services to enable our customers to focus on their core business. Scania is also a leading provider of industrial and marine engines.

As Scania says itself on the webpage, "our value creation is underpinned by our corporate culture, which we call The Scania Way. Deeply ingrained in our business, this culture is based on six core values that reflect our way of thinking and guide our day-to-day actions and decision-making. They support us in creating value for our stakeholders and ultimately, in our aim to be the leader in the shift towards a sustainable transport system ". (*The Scania Way*, 2021)

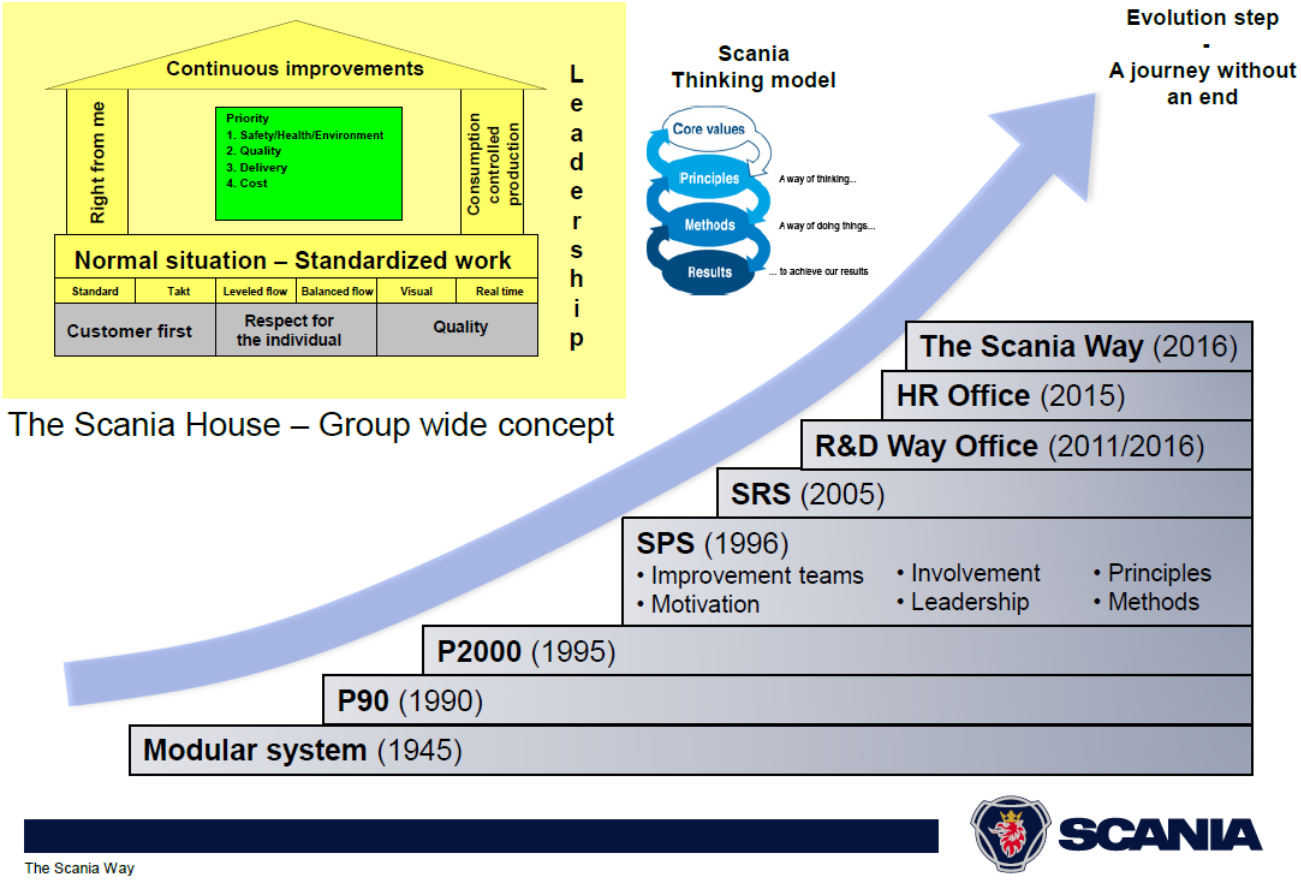


Figure 19 The Scania way (Lyckström, 2016)

Figure 19 shows the picture about the development of the Scania production, taken from the presentation of senior vice president of Scania, Martin Lyckström.(Lyckström, 2016)

One of the base components for success of Scania is their modular system what allows to offer an extremely wide portfolio of products using relatively few components and parts. Product modularity is a beneficial and sustainable method of designing a product, where product architecture consists of physically detachable units (modules).

Scania's modular system main principals:

**Standardised interfaces** – new components can be installed to improve product performance without the need to change the surrounding components and structure.

**Same need, identical solution** –the same components can be used for different applications.

**Well-balanced performance steps** –specific customer needs with differences in cab sizes, engine output, frame strengths and number of axles can be matched.

Due to modularisation new technologies can be introduced rapidly to the market.

Started as skilled craft work, Scania production has been developed into assembly line production. The work processes were repetitive.

By the 80-s Scania has faced the typical problems in production with different working solutions, leadership on results only, lack of qualified manpower. Scania was struggling in these years to hire qualified production personnel and to manage high rate of absence.

In the beginning of 1990s, Scania had the same personnel problems. The company was in need to adopt new approach of production management. Leading engineers were sent to Toyota company in Japan to learn and study TPS in original place. It came out, that management and people in Toyota are of primer matter than standardisation or robotization itself.

The lean house (SPS) of Scania is similar to lean house of Toyota but adopted to the individual needs of the company.
Exactly like TPS, SPS is relying on core values, main principles and important priorities, each employee knows and understands.

SPS together with Scania Retail System (SRS) are the parts of the Scania philosophy, what is called the Scania Way. The Scania Way is the management approach, similar to the Toyota Way, or it could be called also lean approach.

There are 6 core values that form the bases of the Scania Way, described in Figure 20. The first three (customer first, respect for the individual and elimination of waste) have been with the Scania company from the beginning and are of great importance.

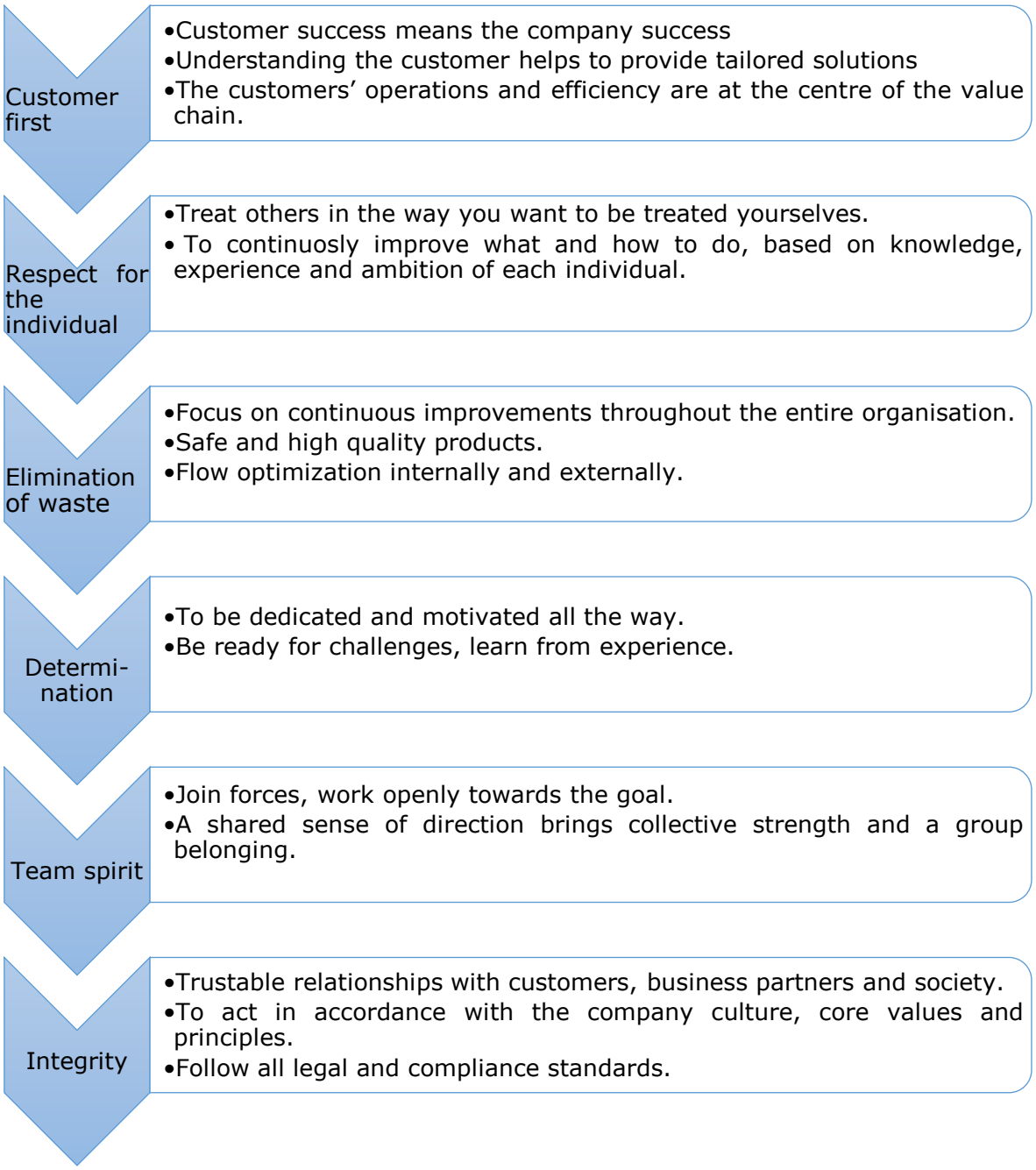


Figure 20 Core values of the Scania Way (Lyckström, 2016)

There are following **priorities** in the centre of the SPS house, everybody in the company has the same:

1. Safety / Health / Environment
2. Quality
3. Delivery
4. Cost

These priorities are compulsory set, what means – priority is uncompromising safety at the same time as consistent quality, on time delivery and competitive cost.

**Right from me** is similar to Toyota jidoka principle, in Scania that means right quality from the beginning. The strategy is to use appropriate tools, instructions and methods that make it impossible to make mistakes or errors and so ensure the quality. Everyone should see the next step in the process as a customer.

**Consumption controlled production** is equivalent to Just-in-time principle of TPS - making only what is needed, only when it is needed, and only in the amount that is needed. In other words, produce / get supplies exactly when needed.

**Continues improvements** on the top of SPS house seek to improve every process in the company by focusing on enhancing the activities that generate the most value for the customer while removing as many waste activities as possible.

**Normal situation – standardized work method.** Normal situation is built on standardisation, a fixed tact time, levelled and balanced flow through the supply chain. Work should be visualised so deviations can be simply detected with immediate feedback information to the right receiver.

Should it mean, that in order to think perceptively, one must build lean house / the production system of Fors MW and begin with the Fors MW Way? The answer is yes, but every word in the house should be carefully understood and followed by everyone in the company. As the Scania Way brochure clearly states – it is a journey without end.

## 3.2 Lean implementation process

This chapter is about the process of lean implementation.

The main problem with implementing lean is that companies lack a standard process for lean implementation and an outline of the critical steps they need to take to achieve the desired goals. (Miina, 2012a)

Especially, when the company has already installed some lean techniques and is basically in the middle of the implementation process, issues such as lean maturity and lean implementation roadmap arise.

Author will try to find true answer to these questions in the following subchapters.

### 3.2.1 Lean in Estonia

According to a 2011 survey conducted by EAS (Enterprise Estonia) with the help of TalTech University, lean theory was unknown in one in three Estonian companies in 2011. Only 29 % of the manufacturing companies were using that. At the same time lean production conception was one of the main questions asked to the consultants. (Ettevõtluse Arendamise Sihtasutus & Tallinna Tehnikaülikool, 2011)

EAS has given the following recommendations to the enterprises:
1) To investigate production management methods independently and to try to find the most suitable.
2) Enhance ongoing monitoring of equipment efficiency.
3) Increase the level of day-to-day production management and performance monitoring.

### 3.2.2 Challenge of lean implementation

Lean implementation is a challenge for every company. There is not clear instruction book with the set of rules to follow, every company must find its own way, adjusted according to the specific needs of that company.

Lean implementation in Toyota has been based on the 2 main principles: total waste elimination (mura, muri and muda) and full customer satisfaction. Figure 21 shows lean general framework, where the strategic level means to understand value, and operational level – eliminated waste. Hines provided a series of resources showing the evolution of lean thinking from quality, cost and delivery to customer value. In the lean framework, the lean thinking is supported by other improvement approaches such as TQM, agile manufacturing, TPM, production control. (Hines et al., 2004).

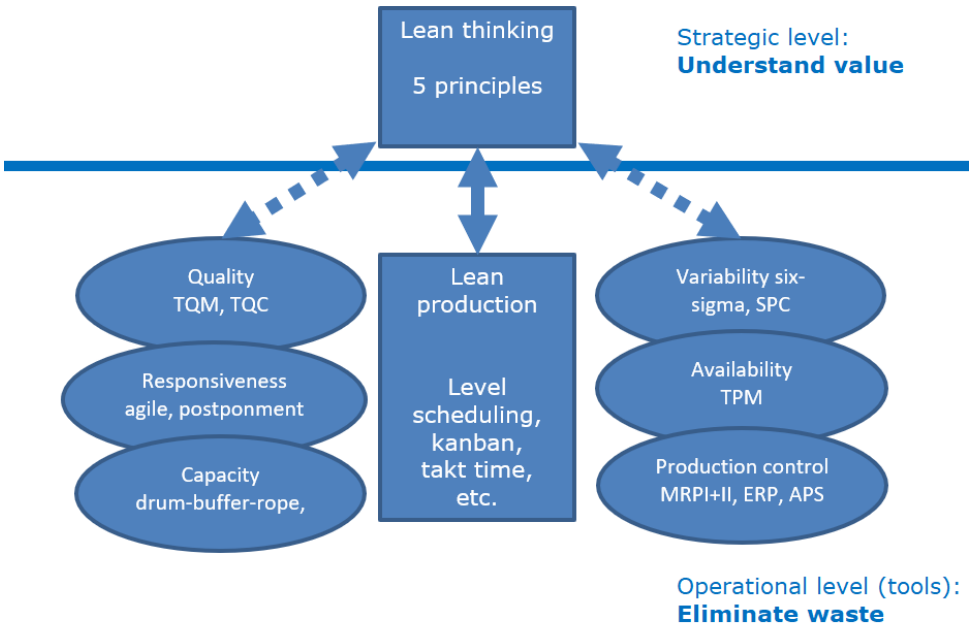


Figure 21 Lean – A Framework (Hines et al., 2004)

Womack and Jones in 1996 identified 5 principles, what should be followed to implement lean. (J. P. Womack & Jones, 2007). They are shown in Figure 22.

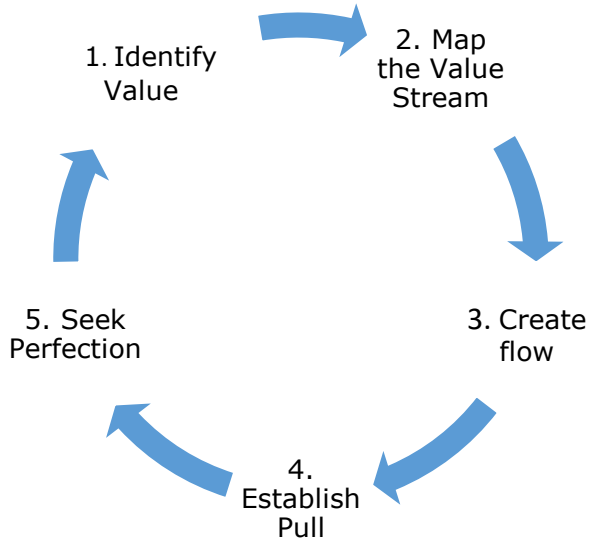


Figure 22 Lean 5 principles

**Identify Value:** Who is our end customer? Value? The value should be calculated in the terms of a specific product, meeting customer expectations in price and delivery conditions.

**Map the Value Stream**: Identify the values stream, what consists of all the processes, needed to make the product ready. Creating Current State map and Future state map of the value stream will help to identify, categorize, and eliminate non-addition value activity.

**Create Flow**: There should be a continuous flow from the beginning to the end of the value stream.

**Establish Pull**: Make exactly as much as needed by customer, and exactly when is needed.

**Seek Perfection**: Strive for perfection by using continuous improvement, eliminating waste, making reliable processes, and generally following the 4 previous principles.

P. Hines and D. Taylor have proposed a roadmap for implementing lean thinking, where the first point, what is lean? – lean thinking and understanding wastes - comes first and involves the whole spectrum of employees from top management to regular workforce. (Hines & Taylor, 2000)

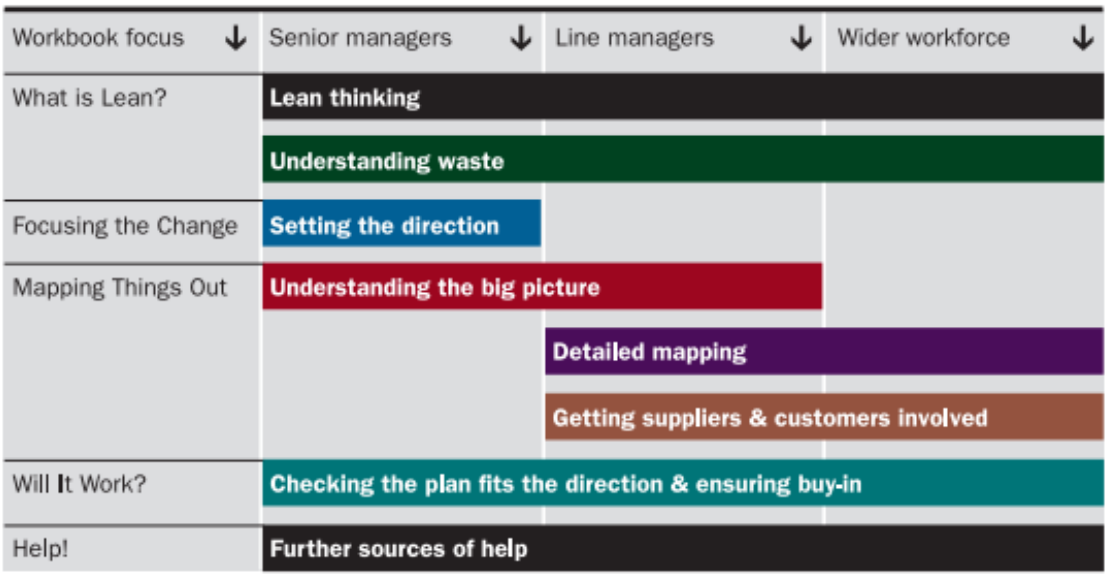


Figure 23 Chart of people engagement in implementation (Hines & Taylor, 2000)

Figure 23 demonstrates the stages and people engagement in the lean implementation process. Author has found it very import to get the lean understanding within the entire workforce.

### 3.2.3 Lean implementation process model

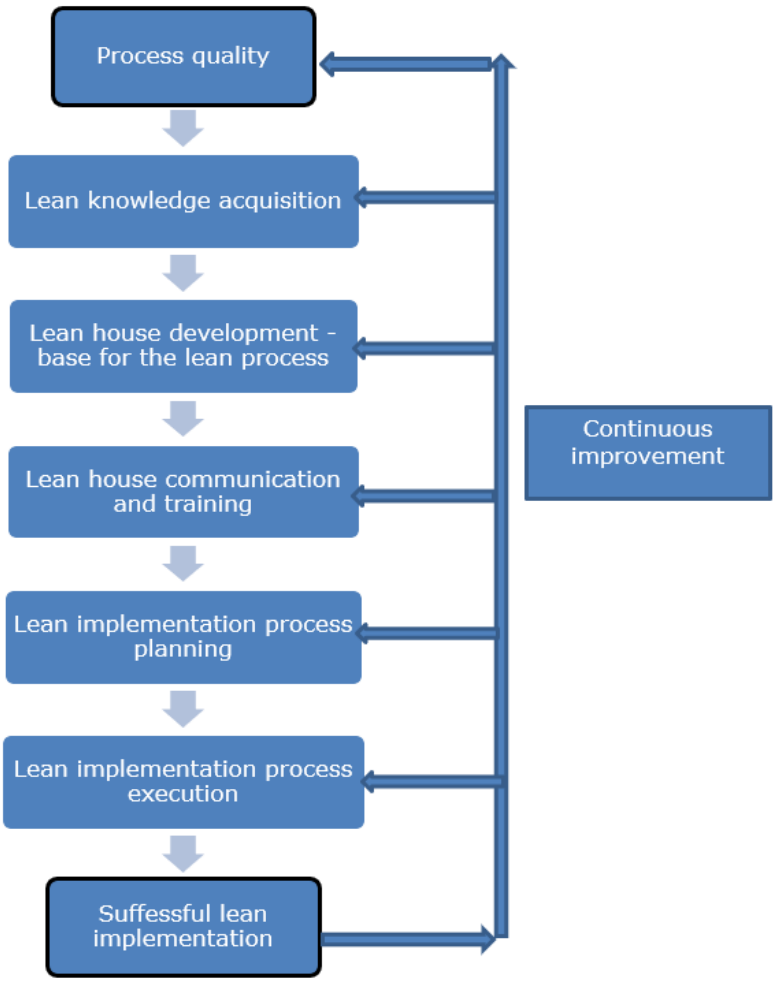


Figure 24 Lean implementation process model (Miina, 2012a)

According to Aleksandr Miina research (model shown in Figure 24) of 2013 year, it is good to use a five-step model with a starting point of process quality, following by the steps: lean knowledge, lean house creation, lean house communication and training, lean implementation process planning and bringing this plan into the life. Since implementation is a non-stop process, the step of continuous improvement closes the loop.

**The process quality** is the basis for improvement - if the company's processes are not standard and the company does not control them, there is nothing to improve, and the idea of lean thinking disappears. Therefore, preliminary work must be done first.

Once the process quality, i.e., the necessary starting point for the entire process of implementing lean thinking, is in place, the **knowledge acquisition of** can begin. The company must gain a deep understanding of what lean means. Various sources of information can be used for this purpose, such as books, consultants, training courses, training, examples from other companies, etc.
Next, all the knowledge gained needs to be tailored to the company, answering questions about what lean thinking means for the company, why it is intended to be implemented, and what benefits it brings to the business. The answers should be put together, and **lean house** must be created. The author's idea of creating the lean house through the prism of the company, proposed in chapter 2.2.4, is confirmed by A. Miina, the creation of lean house is of primary importance, without it the next steps will be neither important nor necessary.
Once lean house is ready, everyone in the organization must learn it, the company must focus on **communication and training**.
Immediately when lean house is created and explained to the organization, it is time to **develop** and **execute a lean implementation plan**.
The execution of lean implementation plan plays an important role in the success of the process. Lean implementation must move from a project approach to a day-to-day work approach.

Two additional steps, such as **evaluation of results** and **corrective actions** can be added to the Lean implementation process model, what creates logical cycle with lean implementation process developing and execution plan. (Tsõgankova & Miina, 2014)

When A. Miina proposed 5-step model for implementation of lean strategy, there are also many others with different approaches. There are also 5-7-9 phases or steps, let us consolidate them under the word „roadmap ".(Steps, 2019)
Roadmap is individual to every company, directly depending on the current situation.

There is a sample of roadmap (Appendix A2.4.3) with 9 steps.

### 3.2.4 Lean implementation problems

Many companies fail during implementation of lean or feel disappointed with the achieved results. (Rubrich, 2004)

There is no clear roadmap or set of rules to follow. (Miina, 2012b)

Author has collected the main reasons of lean implementation problems (Figure 25).


Figure 25 Lean implementation main problems

The author picked ups the problems during the implementation of 5S+Security, what has started in 2016 already. However, even nowadays, there is some resistance from the workers, what author explains by lack of commitment. But commitment of the worker is the result of poor education and not sufficient management support.
Today, when the bonus is directly connected to the KPI of 5S+Safety performance, the workers has shown great possibility for changes in mindset.

### 3.2.5 Lean assessment

Lean assessment is a lean audit, it helps to investigate, evaluate and measure core areas of manufacturing. Assessment is an important method to examine the present state and the future state when implementing lean technique. Lean assessment can be done in nine critical fields of manufacturing for evaluated, which are processes, team

approach, inventory, maintenance, time setups, suppliers, layout/handling, quality, and planning/control. (Qaid et al., 2020)

The evaluation tools can be classified as:

- Quantitative lean assessment, based on questionnaire
- Qualitative lean assessment, based on data and reports
- Observation and interviews

The best methods proposed are lean assessment tool or fuzzy method, both based on quantitative and qualitative assessment. Strength of lean assessment tool is that it provides progressively proficient information regarding estimating the lean maturity level, the weakness is in subjectivity of judgement. Fuzzy method is more flexible in identifying options, but no expansion in studies on the use in improving the design and development of assessment. (Qaid et al., 2020)

Exactly like 5S+Safety audit is done on the weekly base; the company should track the implemented lean techniques performances on the regular base. (Muenzing, 2015)

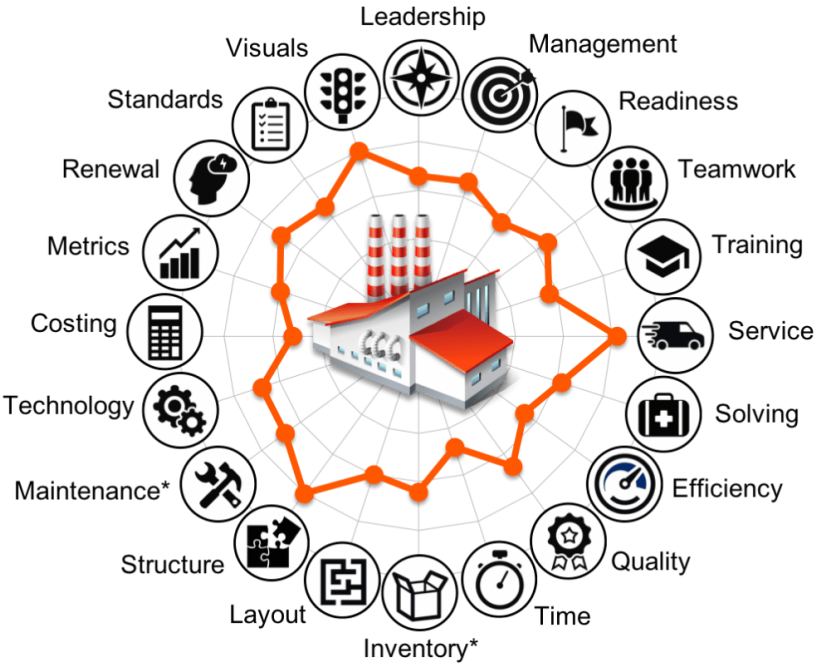


Figure 26 The 20 keys to lean audit (Kobayashi, 1995)

The 20 key elements for the lean audit are shown in Figure 26. (Kobayashi, 1995)

The lean audit checklist consists of set of questions.

# 4. LEAN HOUSE, LEAN AUDIT AND SUGGESTED IMPROVEMENTS

It this chapter the author introduces to you the lean house of Fors MW, results of lean audit and gives further recommendations. Calculations of implementations cost and benefits will be performed.

VSM of the crane assembly together with layout will be proposed by author to minimize lead time and reduce WIP. As last the author will introduce new sales order process.

## 4.1 Lean house of the company

The author has created lean house for the company, based on the core values.

The completed lean house is shown on Figure 27.

The roof represents the goal – high quality customised products at the right time. Fors MW slogan "We make it easy" emphasises, that the products are easy to buy, easy to install and easy to use.

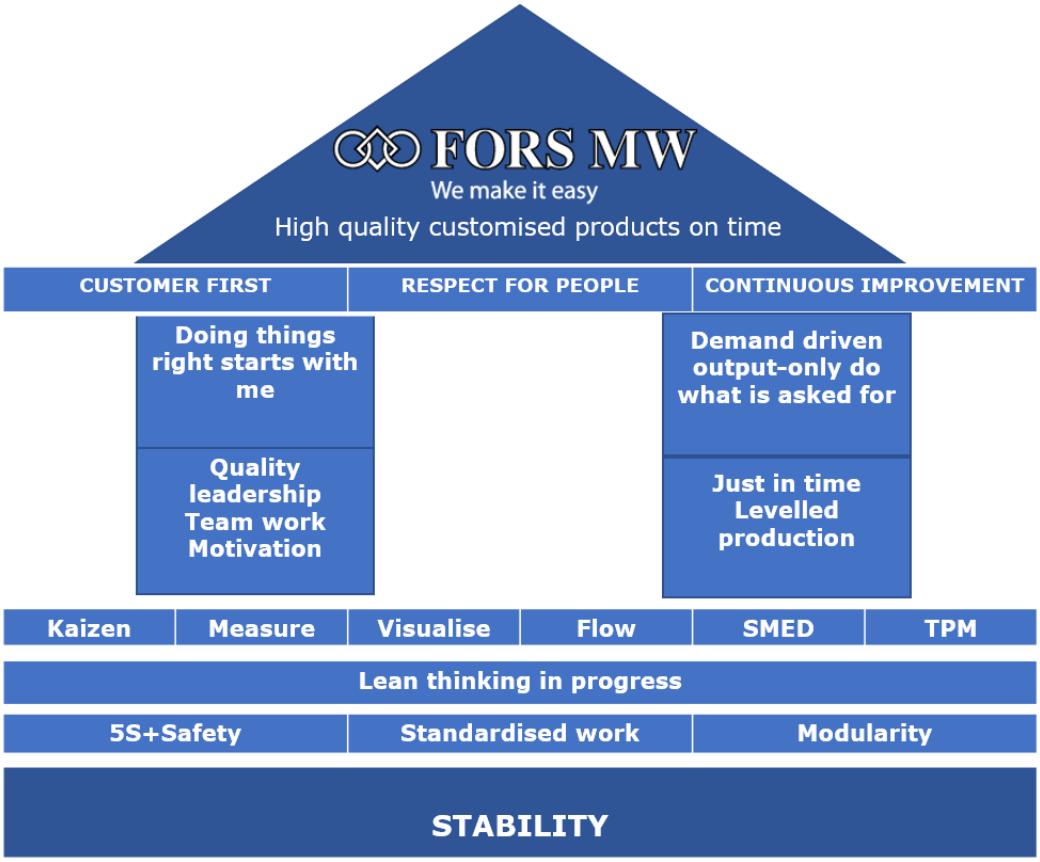


Figure 27 Lean house of the company

There are core values under the roof.

**Customer first** – quality and delivery on time.

The priority is to deliver the required quality on time. Reliable products and services, in all respects are key to the success and create value for customers. Regularity is the basis for high quality and adherence to delivery dates.

The customer is to be valued, customer's expectations are to be researched and learned about.

**Respect for people** - help and support each other.

Treat others as you would want to treat yourself, help and support, learn from feedback. Engage and empower the people closest to the work so they can assess the current state, create solutions to problems and standardize what works.

**Continuous improvement**

The founder of Fors MW Leif Fors was an entrepreneurial person who knew that most innovations are the result of curiosity. Embracing curiosity leads to innovation and that leads to a better product or service. The way to solve the problems that arise is to go and see, find the root cause and base the improvements on facts.

The two pillars represent the working principals.

**Doing things right starts with me –** built in quality and attitude.

Getting things right from the start means that every product handed over is correct and without discrepancies. If errors occur, immediate action and improvement activities must be started.

**Demand driven output-only do what is asked for -** Only do what is needed, in the required amount, where it is needed and when it is needed.

The house is based on **stability**. The keep the stability, the following lean techniques to be used:

- **5S+Safety** – visual management
- **Standardised work** – systematic determination and documentation of work process for each operation
- **Modularity** – modularity as base principle for design
- **Lean thinking** – based on principle value-value stream-flow-pull-perfection
- **Kaizen** – teamwork, improved mindset, active improvement will
- **Measure** – not conflicting metrics with adequate information, not just pure numbers
- **Visualise** – it is some part of 5S+Safety, kanban, quality standards

- **Flow** – flow for the family parts, in ideal world 1 piece flow from the beginning: smooth process from the first moment of getting the order till the order is shipped.
- **SMED** – quick changeover
- **TPM** – holistic equipment maintenance

## 4.2 Lean audit results

The questions for the audit are based on I. Kobayashi's 20 keys to Workplace Improvements. (Kobayashi, 1995).

The author has answered the questions individually. In future this audit can be done once per year by the team leaders. At least 1 year is needed to have sufficient gap to track the changes.
The author has done also qualitative and quantitative analyses.

For each section, the possible answer is possible in 0-4 score, depending on situation (Table 4-1).

Table 4-1 Lean scoring

| **Grade** | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| **Developing Capability** | Not existent | Trying out | In developing | Continuous improvement | Sustained |

Results of the audit are shown in the Table 4-2.

According to the results, the company has no zeroes (not existent score) and lean maturity level is close to 2 (1,79), what means that the company is in active stage of lean developing.

The best performance is connected to 5S+Safety, the least is connected to SMED.
Value stream mapping, plant layout and information and production flow are the areas, where more training and developing is needed.

However, author would like to emphasise the leadership commitment – without that lean organization will not be developed.

Second very important accent should be put on kaizen or continuous improvement. Continuous improvement should be driven not only by reclamation, but also by willing to raise productivity and efficiency.

Table 4-2 Audit assessment

| Lean Element | Grade | Comment |
|---|---|---|
| **Leadership Commitment** | 2 | **In developing:** The management of the company is fully aware of lean and understands it. They mostly do not lead the lean programme. Employees are let to do implementing change. Employee engagement is also limited. |
| **5S+Safety** | 3-4 | **Sustained:** 5S audits are performed on the regular basis. Materials, tools and equipment have permanent locations; workplaces are clean. Standardization is in the focus. |
| **Value Stream Mapping** | 1 | **Trying out:** only few people have been trained in value stream mapping. There have been some processes that have been mapped, but no improvements have been seen. |
| **TPM** | 3 | **Continuous improvement:** Daily and weekly TPM schedules are set and working. The operators carry out basic preventative maintenance functions. |
| **SMED (quick changeover)** | 0-1 | **Trying out:** Machines and processes set up times are known, but they are not 100 % true. Production orders consider them. There is very little knowledge about quick changeover thinking. |
| **Information and product Flow** | 1 | **Trying out:** Flow principle is known in the company, but not used widely. The production is based mostly on batches, job style is firefighting. Some analysis attempts have been done. |
| **Pull (Kanban)** | 2 | **In developing:** There's some use of Kanban in the production. Kanban board are well visualized. There are skilled people in the company. |
| **Plant Layout** | 1-2 | **Trying out:** Historically, the plant location is very messy. Some machines and equipment have been set based on functionality (machining and welding). High WIP inventory. The biggest problem is the distance. |
| **Standard Work** | 2 | **In developing:** Some processes and methods are precisely described (for example welding standard work, quality inspection, scrap reporting, separate sales / purchasing processes etc), but there are many white spots. |
| **Lean Supply-chain** | 1-2 | **In developing:** The suppliers are getting forecasts. Pull system (kanban) has been settled with single suppliers. Suppliers' performance is measured. Price is still the main motivator for purchasing argument. |
| **Continuous Improvement Framework (PDCA approach)** | 2 | **In developing:** PDCA approach is used to investigate nonconformities (inhouse and customers claims). Some improvement methodology is being used. Continuous improvement and problem solving is mostly driven by reclamations. |
| **Visual Management and Accountability** | 2 | **In developing:** KPI are measured on regular basis, but no clear actions are taken. |
| **Training & Development** | 2 | **Developing Capability:** There are skill matrixes in production, but no valid training and development plan. |

### 4.2.1 Lean tools implementation

How expensive is it to implement lean?

The author is certain, that lean thinking and lean principles can be learned within the organization. But yes, hiring a lean specialist or using consulting firm makes learning lean smoother. The cost are brought our in the Table 4-3.

Table 4-3 Lean tool implementation costs

| Lean Element | Lean technique / solution | Implementation cost | Keeping cost |
|---|---|---|---|
| **Leadership Commitment** | Leadership team to be created | 1 person in office, 2 persons in production - salary of 3 persons | 3 persons wages per year |
| **5S+Safety** | | Successfully implemented | Built in quality and production controller wages |
| **Value Stream Mapping** | VSM, spaghetti diagram | Lean specialist | 1 lean specialist wage per year |
| **TPM** | | Implemented | Built in technologist wages |
| **SMED (quick changeover)** | SMED | Training, meetings | Built in technologist wages |
| **Information and product Flow** | FMEA | Lean specialist | Built in lean leader wages |
| **Pull (Kanban)** | | Partially implemented | |
| **Plant Layout** | | To make a plant layout, you need 1 consultant or lean specialist inside the company, but to make changes according to the new layout depend on the changes | |
| **Standard Work** | | New technologist | Built in technologist wages |
| **Lean Supply-chain** | | Partially implemented | |
| **Continuous Improvement Framework** | Kaizen | Kaizen groups, meetings | Built in lean leader wages |
| **Visual Management and Accountability** | Global Reader, Scrum board | Implemented | |
| **Training & Development** | Matrix training | Workforce training | 5 % from year wages fond |

Since the company has good experience to implement 5S+Safety and TPM, it is much easier to start the next projects in the company. VSM creation, spaghetti diagrams, plant layout is a normal job for plant managers.
The author recommends training the specialist in the company.
However, additional managers and lean specialists are still needed for coordination.

### 4.2.2 SMED implementation

Set up cost is the cost of the time, spent for changes the products.
SMED was invented by Shigeo Shingo.
The products in the company, according to Monitor data, have 20% - 40 % of the total time for set up time. One sample is shown in Figure 28.

**Operations** — Showing values per pcs.

| Part no. | Op. | | WC | Quantity | Setup time | Unit time | Total time |
|---|---|---|---|---|---|---|---|
| FMWS20282 | 99 | Picking for welding | 99 | 1 | 2,92 | hrs. | 0,29 hrs. |
| | 103 | Tack-Welding Container | 103 | 1 | 0,25 | 8,00 hrs. | 8,03 hrs. |
| | 104 | Robot Welding MH50-20 | 130 | 1 | 0,25 | 3,00 hrs. | 3,03 hrs. |
| | 113 | Welding Container | 113 | 1 | 0,25 | 1,50 hrs. | 1,53 hrs. |
| | | | | *Total:* | *3,67* | *12,50 hrs.* | *12,87 hrs.* |
| | | | | **Total:** | **3,67** | **12,50 hrs.** | **12,87 hrs.** |

Figure 28 Operation setup time for chassis

SMED implementation consists of 4 phases:

Table 4-4 SMED implementation steps

| **SMED steps** | **Leveraging tools** |
|---|---|
| SMED project starts | Analyse the activities to divide internal and external operations |
| Separate **internal** operations from **externa**l operations | Use the checklist.<br>Function definition for every operator<br>Tool transportation improvement |
| Convert **internal** operation to **external** operations | Setup previous version<br>Automation of operations<br>Utilization of different tools |
| **Improve** all aspects of the set-up operations | Improvement of transporting and storing of the tools.<br>Elimination of setting, calibrations and adjustment<br>Automation of operations |

Regarding implementation costs – according to Jones Malcolm, the first 50% reduction is free, being mostly organisational changes, the next 25% is inexpensive, being mostly small equipment modifications but the final 20% can be expensive, demanding major tooling changes. (Malcolm, 2011)
So if the 50 % reduction is possible as organizational changed, then the immediate profit will be 10%-20% of total time, what allow to raise productivity at least 10 %.

## 4.3 VSM and production layout on the sample of crane assembly process

The author has created VSM on crane assembly.

- Crane assembly is the process of assembling cranes according to the real customer orders (with defined hydraulic information and packing instructions).
- One of the core processes in assembly.
- Crane assembly is a process with low automation (only everyday instruments, industrial hoists and testing tools are used).
- The company requires 30 cranes a week, which was previously possible through overtime / rental workers.
- The bottleneck is testing/packaging**.**

Crane assembly consists of the following operations such as turnhouse assembling, outer boom assembling, crane assembling, hydraulic connection, testing and packing.

A current and future state of mapping is in Appendix 2. The production layout before and after is in Appendix 3. (the author has created them for the lean operation homework with the team students)
The proposed changes include kanban for the turnhouse production, pull strategy, flow process. The change in production layout is minimal and does not require a large investment.

The author sought to show, that the proposed changes in process and layout would achieve the following benefits:

1. 20 minutes shorter crane assembly process.
2. The testing/packaging phase as a bottleneck has disappeared.
3. The same number of people are employed, the work is more evenly distributed.
4. Production visualisation of the process.

5. Shorter lead time (reduction from 14 days to 1 day)
6. Low inventory stock

## 4.4 Improved sales order process

The need to make new sales order process, what will cover the whole process from the moment, when the dealer sends the order, till the end, when the dealer receives the ordered trailer, is not a new one.
There are existing processes for the order handling department, how to handle the incoming customer orders. There are also valid separate processes for manufacturing, separate processes for design, but the uniting consolidation and teamwork is poor.

Due to increased customer dissatisfaction (on-time reliability is 64 % in average), long delivery times, unclear rules and confrontation between the involved departments, the decision to make new process with lean approach was laid to the table.

The author was a witnesser to the last version of the sales order process from 2016 year, when the production planner had to confirm production delivery day to the order handler, who then confirmed the delivery date to the customer. This system never worked properly. The production was in batches, mostly based on forecasting, WIP and safety stock was high.

What means lean approach in that process? Understanding customer importance and value and trying to continuously increase it. When the process is agreed, it is possible to start to make positive changes too.

New sales order process draft is added as Appendix 4.
On the timeline is the milestones information.
Activities are introduced shortly by involved department. Output is clearly defined.

Now, when the company aim is to manufacture what is needed and when is needed, the sales forecast is vital mainly for the long-term outsourcing and manufacturing capacity calculation in long perspective.

Sales order, when received, should be checked for the feasibility according to the valid price lists. In case of design changes, the design task is to be issued.

The delivery time is calculated based on the capacity rules. The capacity rules set is agreed to the production department and confirmed by the company management.

Between order registration and order assembling is normal manufacturing process / purchasing process.

The most important agreement is to freeze the assembling production plan 2 weeks prior to delivery. This decision is caused by the last negative experiences of the mess due to last-minute changes. Manufactured parts should be produced, and purchase articles arrivals should be secured 2 weeks prior to delivery. Loading plan is to be created, and production passes to be printed out.

Within 2 frozen weeks the manufacturing order will be picked up from stock, assembled, if needed cosmetically painted, tested, inspected, and loaded.

# SUMMARY

Lean as a strategy to eliminate waste and improve the performance of the company was developed in Toyota. The successful implementation of lean was proven by example of the Scania Way.
Today lean principles are well known in many industries and companies of all sizes, including service and start-up companies.

When the company is lean, it simultaneously achieves:

- Minimal possible stock of raw materials, WIP, half-ready and finished goods
- Minimum quality issues such as nonconformity, rework, scrap
- Minimal production losses (due to 8 wastes)
- Minimal possible cycle time and minimal lead time
- Minimal variability in production rates and process
- Minimal unit cost of production
- Excellent results in on-time delivery performance, customer satisfaction and gross profit
- Continuous improvement in market share – the company today is better than yesterday, but it will be even better tomorrow.

(Moore, 2007)

The essence of the lean approach is five basic principles – determine, what is adding value and what is not from the customer point of view; identify the waste; create the flow; produce only what is pulled by the customer; strive for perfection.
The main objective of the thesis was to prove, that lean approach in production and sales can increase the efficiency of the company and achieve the company goals by 2025 year.
The author has done an analyse of the current situation of the company. The poor on-time delivery performance needs to be improved from 64 % to 90 %. Fishbone analysis has revealed the deep root causes to be solved.

The company is not a newcomer to lean implementation. 5S+Safety and TPM have been successfully implemented. However, there is still resistance within the workforce, which only began to melt away after the bonus was introduced as a part of 5S+Safety performance.

There is no clear answer, as to how far lean implementation has progressed, as there are no clear rules to measure this. The author has conducted individual qualitative and

quantitative analysis of the lean maturity level, based on 20 key questions. The result 2 point from 4 (in developing) is positive, being still subjective.
The deeper analysis should be done to check the lean progress, for example LAT (lean assessment tool) is proposed. (Pakdil & Leonard, 2014).

For the next lean tool implementation, the author has suggested SMED. The setup time is 20% -40 & of the total unit time, and in case it is reduced by 50 %, at least 10 % of the production time is freed up, and efficiency is increased.

To prove the efficiency of the lean approach, the author has carried out value stream mapping of the crane assembly process along with the plant layout. By applying this approach, there are clear benefits – value added process will be 20 minutes shorter, the testing/packaging phase as a bottleneck disappears, work is distributed more evenly, lead time becomes shorter, inventory becomes lower.

In order to increase customer satisfaction and make production more stable, the design of the new sales order process was introduced. The coordinated and transparent process is an important step of standardization.

The best think about the lean approach is that it does not require a huge investment, but it does require time and patience. The lean approach is a long-term strategy, that allows to achieve great success with small steps, and is highly recommended to all the companies.

# KOKKUVÕTE

Lean-juhtimise strateegia kui raiskamiste kõrvaldamine ja ettevõtte tegevusfaktorite parandamine sai alguse Toyotast. Lean tootmise edukat rakendamist sai tõestatud Scania Way mudeli põhjal.
Tänapäeval on lean-põhimõtted hästi tuntud paljudes töösektorites ja igas suuruses ettevõtetes, sealhulgas teenindus- ja start-up ettevõtetes.

Kui ettevõte on kulusäästlik , saavutab see samaaegselt:
- minimaalset võimaliku tooraine, WIP, poolvalmis- ja valmistoodete varu
- miinimum kvaliteediga probleeme, nagu mittevastavusi, ümbertöötamist, jääke
- minimaalset tootmiskadu (8 raiskamist)
- minimaalset võimaliku tsükliaega ja minimaalset tööaega
- minimaalset ühiku tootmiskulu
- suurepäraseid tulemusi õigeaegse tarnimise, klientide rahulolu ja brutokasumi osas
- turuosa pidev paranemine - ettevõte on täna parem kui eile, kuid homme on see veelgi parem.

(Moore, 2007)
Lean-juhtimine koosneb viiest põhiprintsiibist - määrake kindlaks, mis toob lisaväärtust ja mis mitte kliendi seisukohast; tuvastage raiskamisi; looge pidev voog; tootke ainult seda, mida klient soovib; püüelge täiuslikkuse poole.

Lõputöö põhieesmärk oli tõestada, et lean-juhtimine tootmises ja müügis võib suurendada ettevõtte efektiivsust ja aidata ettevõttel saavutada püstitatuid eesmärke aastaks 2025.

Autor on teinud ettevõtte hetkeolukorra analüüsi. Õigeaegse kohaletoimetamise halba tulemust tuleb parandada 64%-lt 90%-le. Ishikawa diagramm on paljastanud ulatuslikuid probleeme, mis vajavad lahendamist.

Ettevõte ei ole lean tootmises uustulnuk. 5S + Safety ja TPM (seadmete tulemuslik hooldussüsteem) on edukalt juurutatud. Tööjõus on siiski endiselt vastupanu, mis hakkas sulama alles pärast boonuse sidumist 5S + Safety näitajatega.

Selget vastust selle kohta, kui hästi on lean tootmise juurutamine edenenud, pole, kuna selle mõõtmiseks ei eksisteeri selgeid reegleid. Autor on viinud läbi 20 põhiküsimuse põhjal lean-juhtimise taseme individuaalse kvalitatiivse ja kvantitatiivse analüüsi. Tulemus 2 punkti 4-st (arendamisel) on positiivne, olles siiski subjektiivne.

Selgemate edusammude kontrollimiseks tuleks läbi viia põhjalikum analüüs, näiteks on välja pakutud LAT (Lean auditi töörist). (Pakdil & Leonard, 2014).

Järgmise lean süsteemi juurutamiseks on autor välja pakkunud SMED-i (protsesside optimeerimise tehnika). Seadistamisaeg on 20% -40 & kogu ühikuajast ning juhul, kui seda vähendatakse 50%, vabaneb vähemalt 10% tootmisajast ja efektiivsus suureneb.

Lean-lähenemise tõhususe tõestamiseks on autor kaardistanud kraanade koostamise protsessi väärtusahela koos tehase paigutusega (praegust olukorda ja tuleviku versiooni). Tuleviku lähenemisviisi rakendamisel on selgeid eeliseid - lisandväärtuse protsess on 20 minutit lühem, testimise / pakendamise etapp kitsaskohana kaob, töö jaotub ühtlasemalt, tarneaeg lüheneb, varud vähenevad.

Klientide rahulolu suurendamiseks ja tootmise stabiilsemaks muutmiseks tutvustati uue müügitellimisprotsessi. Kooskõlastatud ja läbipaistev protsess on oluline standardimise samm.

Parim osa lean-juhtimises juurutamises on teadmine, et see ei nõua suuri investeeringuid, kuid nõuab siiski aega ja kannatlikkust. Lean-juhtimise lähenemine on pikaajaline strateegia, mis võimaldab saavutada suurt edu väikeste sammudega ja on soovitatud kõikidele ettevõtetele.

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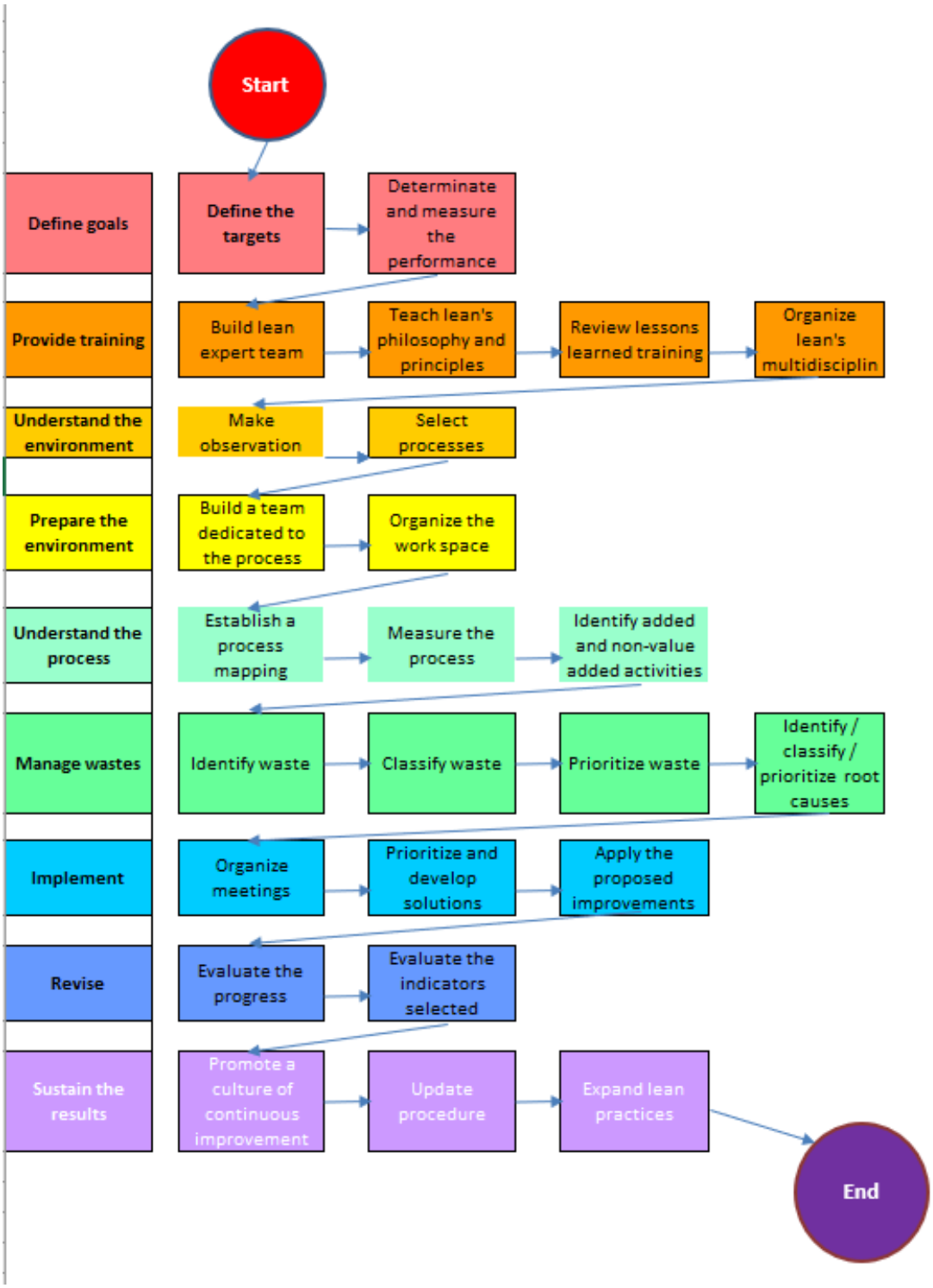
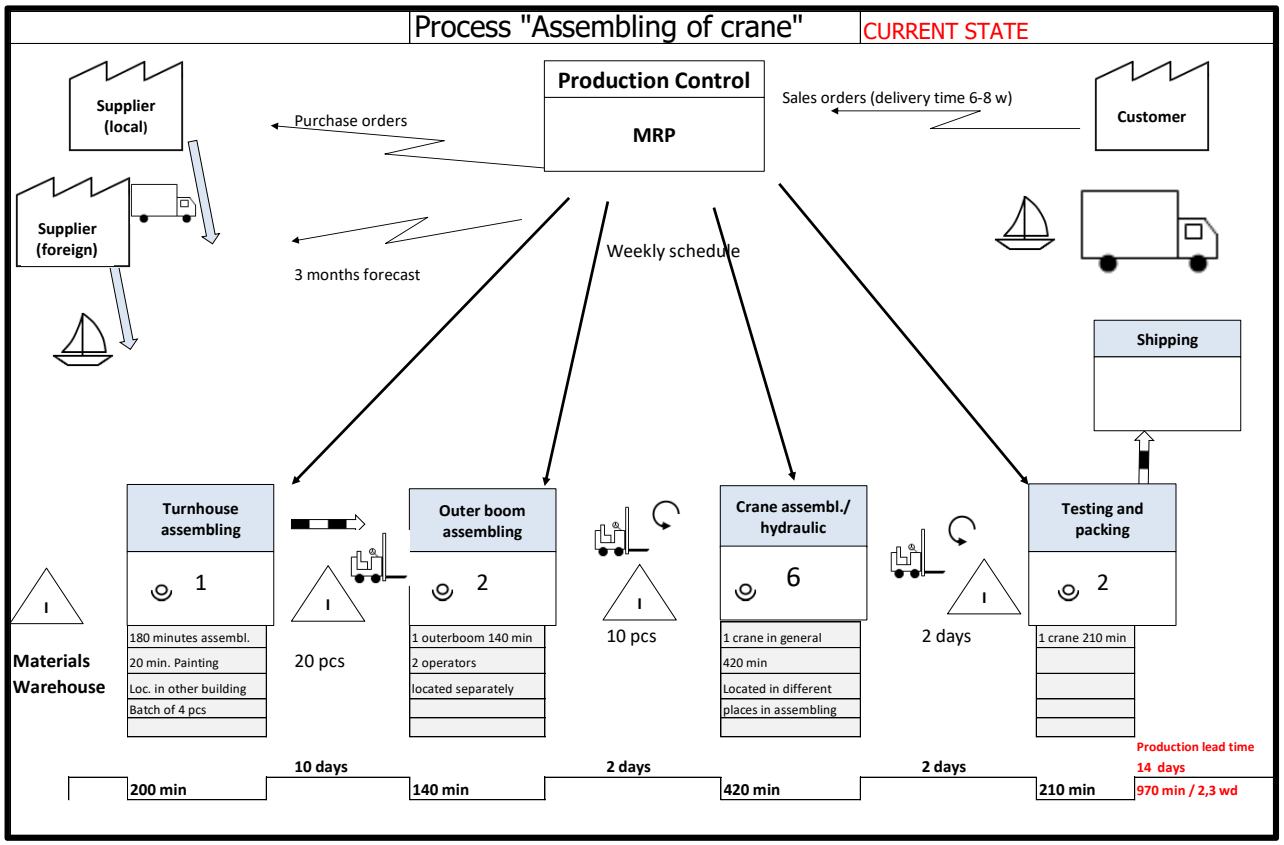
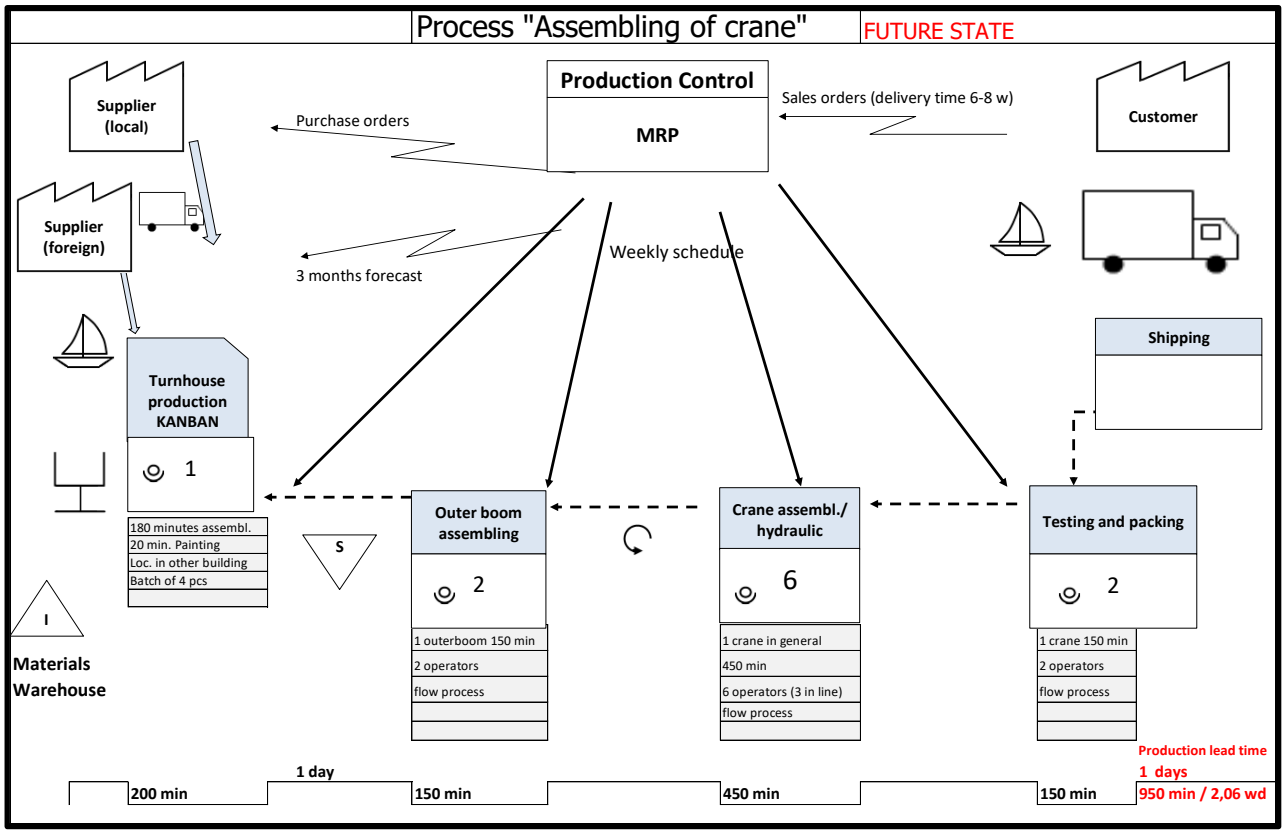
# APPENDICES

## Appendix 1 9 step lean implementation



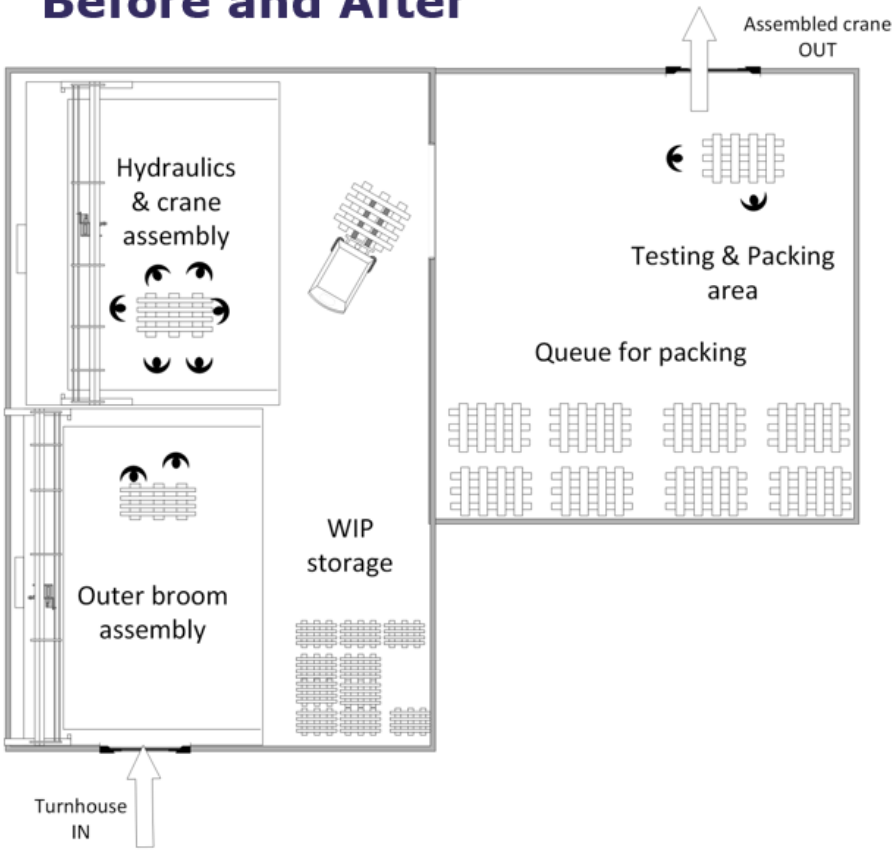
## Appendix 2 VSM of crane assembly

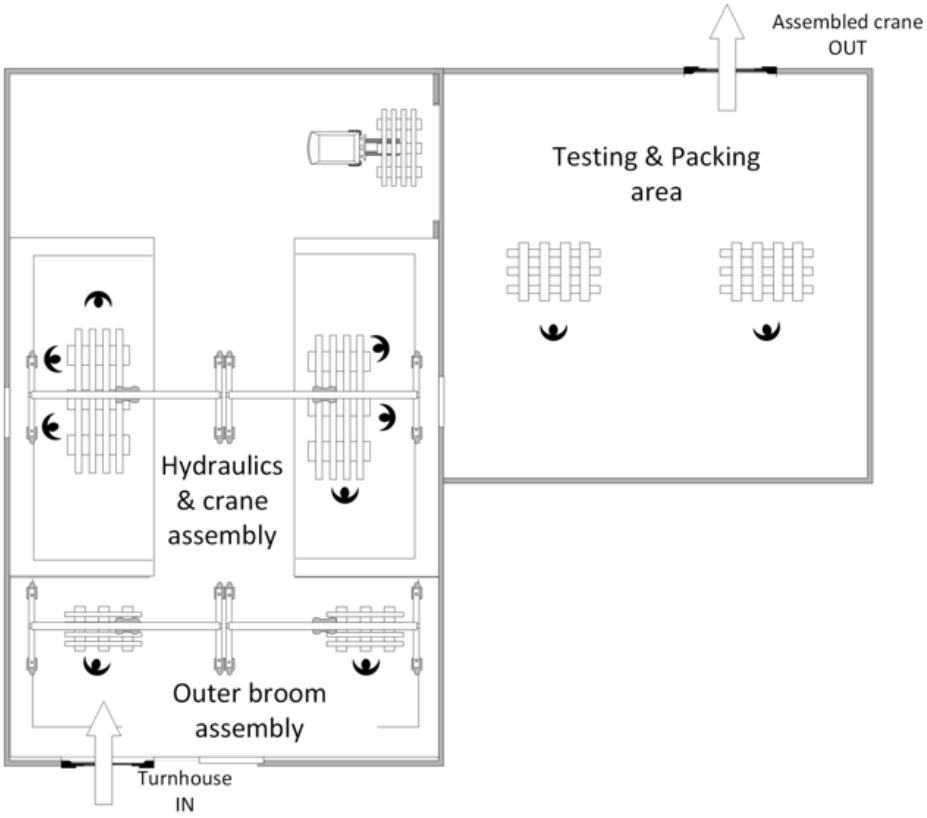


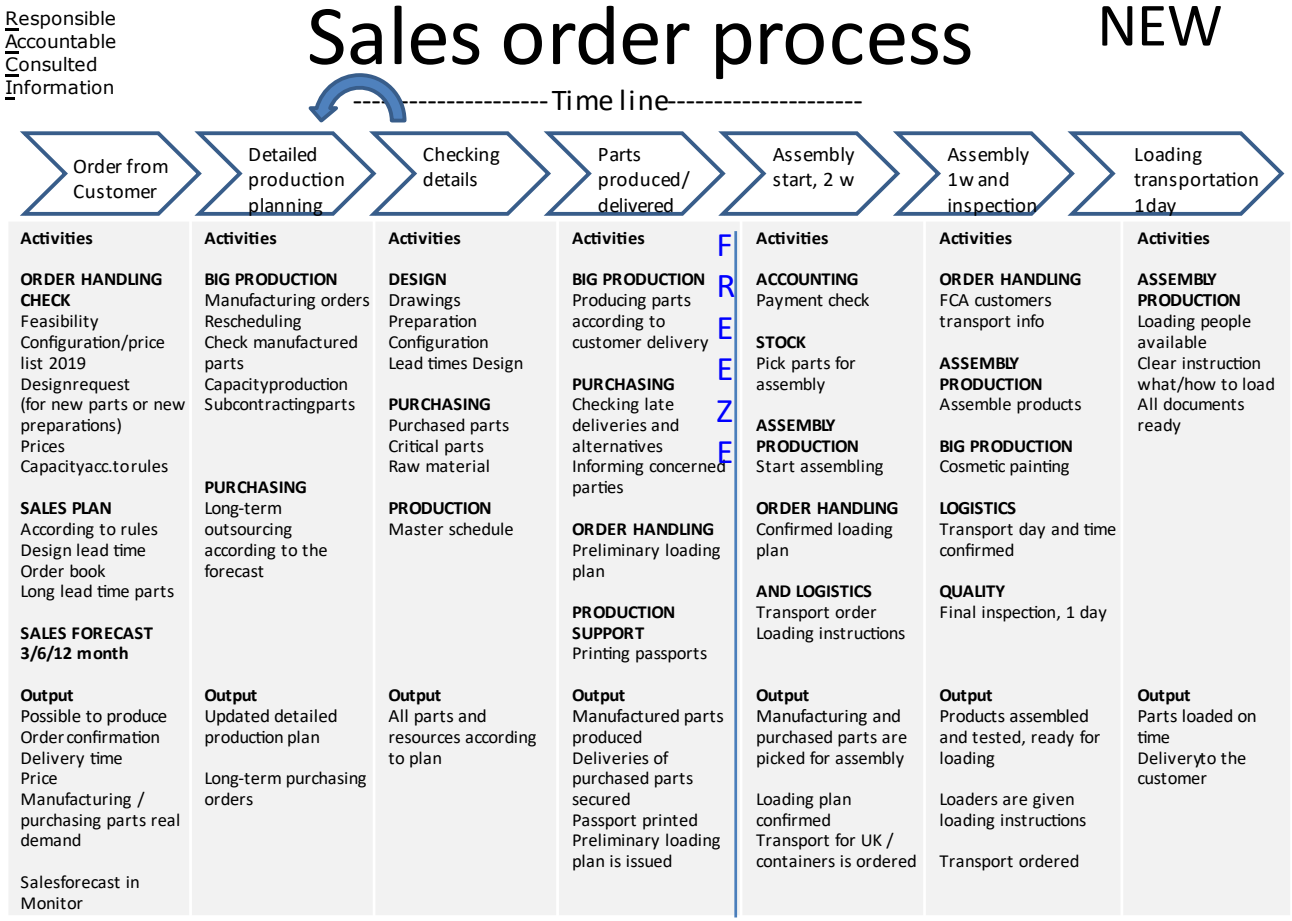



**Appendix 3 production layout before and after**

## Production layout Before and After




Responsible
Accountable
Consulted
Information
Sales order process
NEW
Time line
Order from Customer
Detailed production planning
Checking details
Parts produced/ delivered
Assembly start, 2 w
Assembly 1w and inspection
Loading transportation 1day
Activities
ORDER HANDLING CHECK
Feasibility
Configuration/price list 2019
Designrequest (for new parts or new preparations)
Prices
Capacityacc.torules
SALES PLAN
According to rules
Design lead time
Order book
Long lead time parts
SALES FORECAST 3/6/12 month
Output
Possible to produce
Order confirmation
Delivery time
Price
Manufacturing / purchasing parts real demand
Salesforecast in Monitor
Activities
BIG PRODUCTION
Manufacturing orders
Rescheduling
Check manufactured parts
Capacityproduction
Subcontractingparts
PURCHASING
Long-term outsourcing according to the forecast
Output
Updated detailed production plan
Long-term purchasing orders
Activities
DESIGN
Drawings
Preparation
Configuration
Lead times Design
PURCHASING
Purchased parts
Critical parts
Raw material
PRODUCTION
Master schedule
Output
All parts and resources according to plan
Activities
BIG PRODUCTION
Producing parts according to customer delivery
PURCHASING
Checking late deliveries and alternatives
Informing concerned parties
ORDER HANDLING
Preliminary loading plan
PRODUCTION SUPPORT
Printing passports
Output
Manufactured parts produced
Deliveries of purchased parts secured
Passport printed
Preliminary loading plan is issued
FREEZE
Activities
ACCOUNTING
Payment check
STOCK
Pick parts for assembly
ASSEMBLY PRODUCTION
Start assembling
ORDER HANDLING
Confirmed loading plan
AND LOGISTICS
Transport order
Loading instructions
Output
Manufacturing and purchased parts are picked for assembly
Loading plan confirmed
Transport for UK / containers is ordered
Activities
ORDER HANDLING
FCA customers transport info
ASSEMBLY PRODUCTION
Assemble products
BIG PRODUCTION
Cosmetic painting
LOGISTICS
Transport day and time confirmed
QUALITY
Final inspection, 1 day
Output
Products assembled and tested, ready for loading
Loaders are given loading instructions
Transport ordered
Activities
ASSEMBLY PRODUCTION
Loading people available
Clear instruction what/how to load
All documents ready
Output
Parts loaded on time
Deliveryto the customer