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DEVELOPING WAREHOUSE OPERATOR´S DELIVERY PERFORMANCE WITH THE TOOLS OF LEAN SIX SIGMA

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VARASTON HOITAJAN TOIMITUSVARMUUDEN KEHITTÄMINEN LEAN SIX SIGMA TYÖKALUJEN AVULLA

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Tämä opinnäytetyö toteutettiin suomalaiselle sisälogistiikka yritykselle nimeltään Transval. Transval aloitti yhteistyön uuden asiakasfirman kanssa ensimmäistä kertaa länsirannikolla kesällä 2016. Tehtävä varaston operoitsijana sisältää tavaroiden käsittelyä aina vastaanotosta hyllytykseen saakka ja asiakkaalle toimittamiseen ajallaan. Jos tässä tapahtuu jotain virheitä, aiheuttaa se haittaa sekä asiakkaalle, että Transvalille.

Tämän opinnäytetyön tavoitteena on löytää suurimmat ongelmat, joita ilmaantuu ja aiheuttaa virheitä, kun tavaroita toimitetaan varastolta asiakkaan tuotantoon. Kun ongelmat on löydetty, on tärkeää selvittää niiden juurisyyt ja ratkaisut niiden välttämiseksi ja tuhoamiseksi. Lean Six Sigma on keskeisessä roolissa tässä opinnäytetyössä.

Opinnäytetyön teoreettisessa osuudessa käydään läpi lyhyesti Lean Six Sigma, joka on tämän työn perusta. Teoreettisessa osuudessa käydään läpi käsitteet Lean, Six Sigma, Lean Six Sigma, Minitab, Visio ja DMAIC. Lean Six Sigma on tärkeä osa tätä työtä, sillä empiirisen osuus perustuu siihen ajatusmaailmaan.

Opinnäytetyön empiirisessä osuudessa käydään läpi tutkimuksen tulokset ja analysoidaan mahdollisia parannuskeinoja. Ilmenevät ongelmat kirjataan ylös varastossa, normaalin työn yhteydessä. Tuloksen analysoidaan Lean Six Sigma työkalujen avulla.

DEVELOPING WAREHOUSE OPERATOR´S DELIVERY PERFORMANCE WITH THE TOOLS OF LEN SIX SIGMA

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This thesis was implemented to a Finnish internal logistics company Transval. Transval started to operate first time in west-cost of the Finland with a new client in summer 2016. The warehouse operator´s tasks are receiving the goods, shelving them and deliver all the needed items to customer on time. If there happen some mistakes, both the client and the warehouse operator suffers.

This project is about finding the main problems that exist and causes mistakes when delivering items from warehouse to client´s production department. When problems have been found, it is necessary to find out the root causes and the solutions to eliminate them. The Lean Six Sigma is in crucial role in this thesis.

The theoretical part of this thesis is telling the basic information about Lean Six Sigma. It is the base of this thesis. Theoretical part covers concepts like Lean, Six Sigma, Lean Six Sigma, Minitab, Visio and DMAIC. The Lean Six Sigma is important part of this thesis because the empirical part is based on this mindset.

The empirical part of this thesis discusses the results of the project and analyzes the possible improvements. Data is collected in the warehouse in the real working situations. The result is analyzed with the tools of Lean Six Sigma.

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1 INTRODUCTION

The main reason for this thesis is to eliminate the problems which appears when delivering items to client. Transval is responsible of deliver right items to client, with good quality and on time. Sometimes this is not working and it causes waste of time and monetary harm, both to the warehouse operator and to the client.

The objectives of this thesis are to find out what kind of mistakes and problems appears and how often when Transval delivers items to client production department. When the number of mistakes is known, the results will be analysed to find out the root causes.

The purpose is to find out the root causes of the problems and eliminate them. It is important to improve the operating so that it will last after this project as well. For example, creating new working instructions for the employees if needed is one considerable option.

The theoretical part includes text about the Lean and Six Sigma which are the base of this thesis. DMAIC, Minitab and Visio tools are used when analysing the results more about those are discussed in chapter 4.

The empirical part of the study consists the data collecting and analysing the result. Data collecting is going to be done with a group of six employees. The team will write down the appearing mistakes and group meetings will be held with the team to understand the work better.

The improvements will be shown in the end of this thesis.

2 TRANSVAL

Transval (official name Suomen Transval Group Oy) was founded in 1994 and at the beginning it was operating only in terminal services. Transval has expanded over the years to internal logistics services. In 2014 after the acquisition with Vindea, Transval started to operate in industrial services as well. Nowadays the company divides their operation into four categories: warehouse services, terminal services, industrial services and consulting and human resource services. Transval employs over 4000 professionals of logistics in 20 different locations in Finland. Company's logistics services are always customized for each client because Transval operates with different kind of client companies in different kind of industries.
(Website of Transval, 2017)

Transval started to operate in Rauma, Finland in summer 2016 after making a contract with some big client company. It is Transval's first branch operating in Rauma area. Actually Transval is just starting to expand on west coast of Finland. They had one branch in Pori, about 60 kilometers from Rauma, but it was closed in 2016 after one year of operating. Most of the branches operates in Helsinki metropolitan area.

Transval's tasks is to receive deliveries from suppliers of the client, control the warehouse of the client and deliver items from warehouse to the client's different departments when needed. They have different working groups who are focusing for different tasks.

The client company of Transval wishes to stay anonymous.

3 OBJECTIVES, PROBLEMS AND IMPLEMENTATION OF STUDY

3.1 Purpose and objectives of study

The purpose of this study is to find the major mistakes that appears when Transval delivers components to client's production department. Those mistakes cause waste of time and money for both, to the warehouse operator and for the client. Transval is new operator for this client so it is even more important to handle everything correctly and impress the client.

To find these mistakes, the data of appearing mistakes will be collected with the six-people team. When the data is collected and the mistakes are known, the data will be divided in the groups. Problems that appears most often, are analyzed and hopefully eliminated during the project.

To eliminate these problems and mistakes, it is important to find root causes of these problems. The data will be analyzed with the tools of Six Sigma to find the solutions.

When the root causes are known, it is time to find a way to avoid those mistakes in the future and see what kind of improvements it requires.

3.2 Boundaries of the thesis

Boundaries in this thesis are that the focus is only on mistakes when delivering components to client's production department and ignore the welding department. Transval delivers most of the items to production department and it is physically in different building so the chance of mistakes is bigger. Welding department is in the same building as the warehouse so communication and delivering between warehouse and welding place is easier. Now the delivering to production department causes more problems so the focus in this project is on that.

Focus is also only in the biggest problems which appears when collecting the data. Every single problem is not analyzed in this project. Even if is important to eliminate all those little problems as well, the time schedule of this thesis is tight and the big picture is beheld in this project.

3.3 Research questions

- How much Transval makes mistakes when delivers components to the production department?

- How is it possible to reduce the number of mistakes Transval makes when delivering components to production?

- How can Transval improve their work to achieve better results?

- How Transval makes sure that those improvements will last after this project?

3.4 Conceptual framework

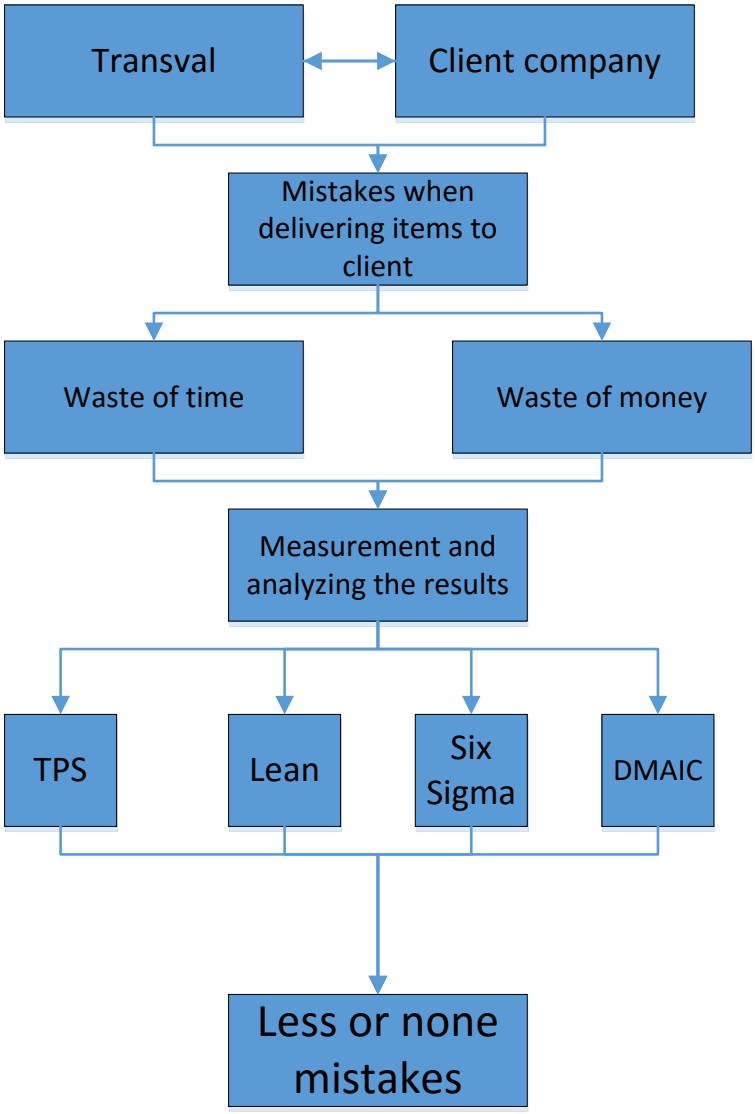

Figure 1. Steps of this thesis. Conceptual framework. (Johansson, 2017)

This conceptual framework describes the main topics and steps of the thesis. First there are the targets of this thesis. Transval and the client company are the reasons this thesis is going to be done.

Next there is the problem that needs to be solved and the main consequences that it causes. Then there are four crucial concepts that are used in the theory of this thesis. Those concepts include the tools that are used to analyze the data which is collected.

The goal of this thesis would be to have as few mistakes as possible.

3.5 Research Methods

Action research and the group discussions with the team are used in this thesis. The task is to find out the main root causes that causes problems when items are delivered to production. Easiest way to collect data in this situation is to write down every problem that appears. In-factory employees, who delivers items to production department, are part of the project team. They are supposed to mark down every problem they faced for a month.

Working team consisted of six people, five in-factory employees and the author. The group is going to have meetings where they can discuss about the problems and possible solutions. More about those are told in chapter 6.

3.5.1 Inductive approach

This research is inductive approach because it is data-driven approach. Data is collected and all the actions are related to this data. The data gives an idea what is the problem and it is also the material that is used to find solutions. Because the inductive approach starts with empirical observations, the meeting with the team was held at first. The team discussed which affects the most for the on-time delivering. The team had very good brain storming session and the results are shown in CTQ in chapter 4. (Pirkanaho, 2017)

3.5.2 Qualitative research

Research method is qualitative in this thesis. Firstly, inductive methods can be used with qualitative research. Secondly, in qualitative research the data is collected in real and natural situations, like in this case. Data was collected by following the normal

everyday work of the employees and marking the mistakes. Also, the fact that the researcher is the most important research instrument is totally true in this case. Everything starts with the researcher, who collect the data. The in-factory employees work all the time with production department and visit in their building so they got the notifications about the mistakes right away.
(Pirkanaho, 2017)

4 LEAN SIX SIGMA

4.1 Lean

Lean is a concept that is hard to explain. It has no one word to describe it. In 1932 Taiichi Ohno started his career in Toyota-concern and he is often called as the father of the TPS. He developed Toyota's production philosophy constantly for 60 years and together with the cousin of Toyota's founder he named the philosophy *Toyota Production System (TPS)*. In 1978 he published a book called *Toyota Production System: Beyond Large Scale Production*.

Taiichi Ohno thought that mass production and resource efficiency is not the way the company should operate. He thought that the goal is to get manufactured goods to flow effectively. In big companies it is common that they have efficient machines and as few employees as possible and those are working all the time so the resources are used well. Ohno changed this thinking model by saying that is it more important to focus on one single item at the time. No matter is it a customer or a product.

It was common that manufacturing companies had huge stocks full of products waiting for possible customers. Companies made mass production and produced lots of productions at the same time and also had stocks full of spare parts. Toyota started to produce specific products to customers. When the order was made, people at Toyota started to react: they made a contact to their supplier and ordered the spare parts, they made a car and sold it. The lead time was maybe longer, but there were no extra parts

and products laying on the stock. This brilliant book was published first only in Japanese and it was translated in English in 1988. Before that, many western authors tried to make understandable text from it but without results. (Modigt & Åhlström 2013, 78-80; Womack & Jones 2003, 59)

Concept *lean production* was seen first time in article written by John Krafcik in 1988, which was published in Management Review-magazine. Krafcik wrote about differences between car manufactures and their production systems, robust and fragile style. In robust-manufacturing, a company has a large buffer inventory stocks, long production runs and employees who are specialized just for some work. Fragile was the opposite. Fragile still had too negative sound so Krafcik created the word *lean*. In 1990 a book called *The Machine that Changed the* World was published. Krafcik's articles was one of the references for this book. *The Machine that Changed the World* was a sales success all over the world. The authors, James p. Womack, Daniel T. Jones and Daniel Roos describes widely what lean production means. They thought that lean consist of four principles: establish a pull system, create one-piece flow, work on tact and strive for zero defects. (Modig & Åhlström 2013, 78-80.)

One of the main ideas of lean is to reduce the Muda. Muda means waste in Japanese. Every acts which causes muda but not create any value should be eliminated, for example processing steps which are not actually needed or transport of goods from one place to another without any purpose. (Womack & Jones 2003, 15.) There are eight types of waste which does not give any value but only causes waste. Organizations should try to reduce these: over production, waiting, unnecessary transporting over processing, huge stock, unnecessary movement, faults and unused creativity of employee. (Liker 2010, 89) The focus of Lean is on producing more goods with fewer resources. Idea is that value is defined by the customer and the supply chain and value stream should flow continuously. (Averill 2011, 1)

Even if there are plenty of books, articles and presentations about lean and TPS, no company can just copy it. Even though Toyota has been extraordinary open about its practices and they willingly show their plants to visitors. Many visitors have started to think that it must be Toyotas cultural roots, which has given its success. Toyota believes that they can show their plants to every company and tourist because even if

someone tries to copy the idea and practice, when they have done it after decades, Toyota is already way ahead again. (Spear & Bowen 1999, 97)

The effective paradox is something that need to be understood to understand Toyota's success. There are three rules of effective paradox which are important to understand the lean.

1st rule: Too long flow times. When company focus just on resource effective working, it affects negatively to customer and employees. If company tries to use its recourses as effectively as possible, it may mean that good or service do not flow fast and smoothly to the next available person or machine. Waiting time between services or steps in production stretch. This causes stocks between production steps or long waiting times between services. When the waiting time is long, it could cause that customer gets frustrated to wait and changes the service provider. It also causes extra work. For example, when products are moved to temporary warehouses and back to production or when the person who offers the service needs to handle the same issues again and again.

2nd rule: Too many flows at the same time. Meaning for example, longer someone postpones of answering for email, the bigger amount of unread mails there will be soon. Too many flows cause a need for bigger warehouses and keeping warehouses means more labor force and more costs. If there are many flows going it causes extra work as well. It is important to focus on limited amount of flows at the same time.

3rd rule: Compulsion of starting again. The email sample again, when there are too many emails waiting for answers, people gets frustrated and do not finish the task at once. Then it means the task need to be started over and over again. Extra work happened to appear in this rule as well. When it is time to start reading the email, one may create a system how to do it, mark the important ones first and delete those which is not so important. One may think now that this is effective working system but reality is that if the emails had been read when those arrived, this would not be necessary extra work to do.

Effective paradox means that organizations waste resources, on the levels of individual, organization and maybe even in level of society. The solution is that organizations need to focus on effective flows. In this way they can eliminate the extra work, the starting again problems and long waiting times for example. Effective flows mean that items are flowing faster and smoother through the organization. This reduces waste of time and money. (Modig & Åhlström 2013. 48-67.)

Getting lean requires everyone in the organization to participate. It is not just an another set of tools and practices to improve the work. It is continuous never-ending process that requires fundamental adjustment in thinking, attitudes and practices. (Caroll 2008, 18.)

4.2 Six Sigma

"Six Sigma is a management methodology that attempts to understand and eliminate the negative effects of variation in our processes" (Goldsby & Martichenko 2005, 5).

Six Sigma has at least three different meanings, depending on context. It is a level of quality that measures the variation in a process. It is a problem-solving methodology that tries to eliminate the root causes of mistakes. Lastly it is a management philosophy to understand that mistakes decrease satisfactions and customer loyalty and increase costs. (Brue & Howes 2006, 6)

Six Sigma- trained employees are green belts or black belts. They have studied Six Sigma course to learn to use problem-solving model. DMAIC is one of the step-by-step tools to improve company's challenges. There will be more about DMAIC later in this thesis.

Six Sigma's idea is to understand and reduce the variations in processes. Especially in logistics, the reduction of variation is very important. For example, if lead time varies between 5 to 10 days, it causes waiting and loss in sales. Ideal would be to regularize the leading days to 8 days, for instance. Logistics is kind of managing the variance all the time (Goldsby & Martichenko 2005, 5.)

Six Sigma is not improvement program; it is system for improving the capability. Variance causes mistakes, mistakes causes faults and faults causes waste. Six Sigma focus on reducing the variance and Lean focus on reducing the waste (muda). In 2002 Lean and Six Sigma united and compounded a combination which brought together the familiar concepts. Now the working with these tool is even more efficient (Website of Six Sigma 2017.)

Most of the projects and services, in profit and non-profit organizations and in government services are kind of process that can be improved by the application of Six Sigma methods. Not every company are automatically suitable for Six Sigma and it is not something to do fast and keep it that way. Six Sigma relied on tried and true methods that is not only focusing on quality improvements but successful development with profitability, sustainability and long term growth. (Pydznek & Keller 2010, xi, 65)

4.3 Minitab and Visio

"Minitab is a statistical software package that is commonly used by Lean Six Sigma practitioners" (Brook 2010, 11). Nowadays it is important that improvements are based on facts. Modifying data to information which can be used when developing the operations and making decisions. Minitab is useful tools for this. Minitab program is popular tool in education, teaching and improvement processes. Minitab is in use in companies like American Express, Polaroid, Microsoft, Nike and Toyota Motor (Website of Six Sigma 2017).

In this project, Minitab is used to analyze the data. Pareto-analysis is made for dividing the data. There are many useful tools on Minitab but in this thesis with this data the pareto was the one to use.

Visio instead was more useful in this project. "Microsoft Visio is a universal graphics program that provides the right tools to visualize most business tasks and technical tasks by using one easy-to-use product" (Website of Microsoft 2017). Visio is used to make swim lane, CTQ and fishbone diagram in this thesis. Many process maps with

the team was made with Visio as well. Every project requires different tools and it is already a skill to learn to notice which are the best tools for which projects.

4.4 DMAIC

Define-Measure-Analyze-Improve-Control (DMAIC) is a logical flow to problem solving. The key to successful Lean Six Sigma project is to understand the nature of DMAIC. (Brook 2010, 2) DMAIC consist of 5 steps which each one of them leads towards to the root causes and solutions. In Six Sigma philosophy, it is important to ask many questions, especially new questions to get new answers and possible result alternatives and proposals. (Ihalainen & Hölttä 2001, 59)

4.4.1 Define

First step is defining the problem. In this stage the researcher should recognize the problem, measure the requirements and set the goal.

4.4.2 Measure

Second stage is measuring the process. Collecting the data and searching more about the problem is the task. Now it is time to finalize the problem and the goal.

4.4.3 Analyze

Analyze the process in next step. Now it is time to analyze the data, make reason-result hypotheses and identify the root causes. Now it should be clear what causes the problem.

4.4.4 Improve

Improving the process means that researcher creates the idea of how to eliminate the root causes. Then the idea is tested and standardized. Finally, the result is measured to see if the improvements works.

4.4.5 Control

In controlling stage, it is time to create the standard measures to maintain the performance in the future. Still appearing problems should be fixed.
(Website of Six Sigma 2017)

5 RESEARCH PROJECT

5.1 Case

Transval is supposed to deliver right items from ILC (integrated logistics center, the warehouse) to client's production department on time. Unfortunately, this is not always working correctly. Client makes notifications if Transval delivers items late, or wrong amount or with bad qualitative. Sometimes Transval has not delivered some item at all. In worst cases this could cause a stop in production and a big monetary harm.

First there is need for searching how many and how often Transval makes mistakes. This is going to happened with the help of Transval In-Factory employees. Those employees of Transval who delivers items to production will write down every notification that they got from client. This follow-up will last for a month or as long as needed to get enough data.

When there is enough data, it will be analyzed. First it is good to separate findings in major groups. When knowing the biggest problems, it is time to focus just on them.

Every single mistake are not analyzed in this thesis, even though those are important to solve as well, but because of limited time and resources in this thesis those will be ignored.

When the major problems are known in work, the root causes of those need to be found. Then the solutions and actions for the future need to be thought.

5.2 Swim lane

This swim lane shows how the component flows through the warehouse. Orange boxes are actions made by Transval. Blue boxes are client's actions.

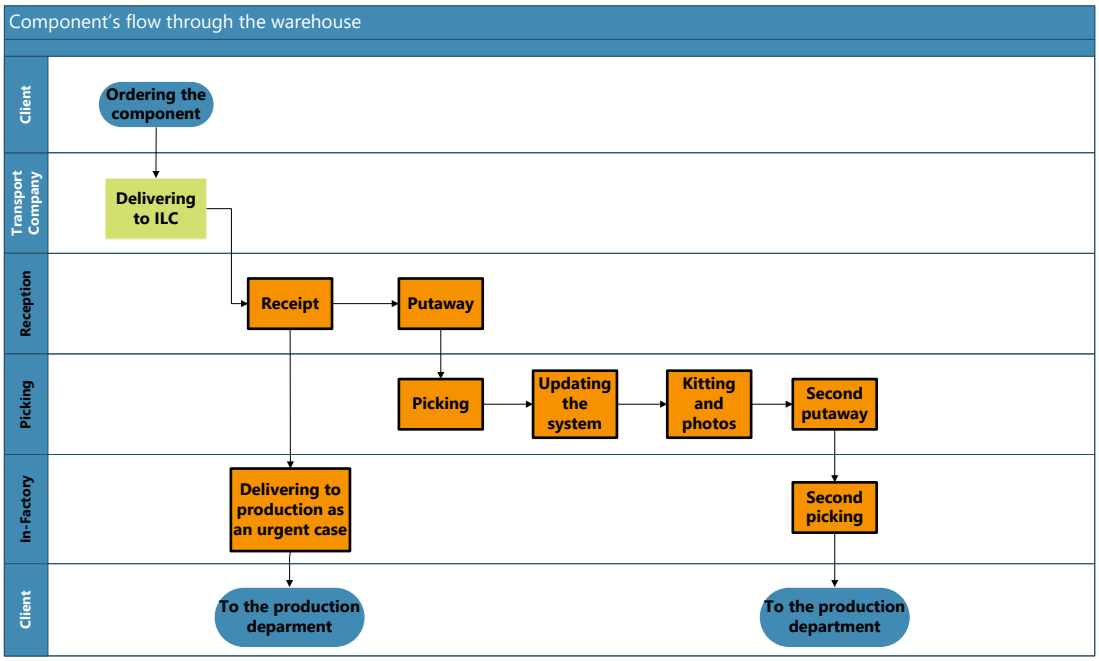

Figure 2. Swim lane. (Johansson, 2017)

First, client orders a component, which transporting company delivers to ILC-warehouse. Then Transval receives the component, puts it in to the system (receipt) and shelves it (putaway). In urgent cases when production department is waiting some component to come immediately, Transval delivers the component right to the production department after it has been delivered to the warehouse. In these cases, it is very important to still remember to update the system. If there is no hurry, the component will be on shelf until Transval get noticed that it is time to do the picking.

Picking can be started five days before there are need for that component in the production department. Employees of Transval have a picking list printed out of a system and they will pick components from shelves, make kitting sets, take pictures of these sets and put them to picking shelves.

When production department needs these components in their work, they make a notification to Transval. After this, Transval has specific time to deliver the sets of components to production. They need to be there right on time, if not, it could cause a stop in production, in worst case.

5.3 Critical to Quality (CTQ)

Critical to Quality is a tool that shows at one look what are the critical acts that need to be done on time to make sure everything is working fine.

Need tells us what is the purpose and *drivers* shows what are the main acts to do to ensure that component is in production department on time. *CTQ* shows needed actions in detail levels.
(Brook 2010, 23)

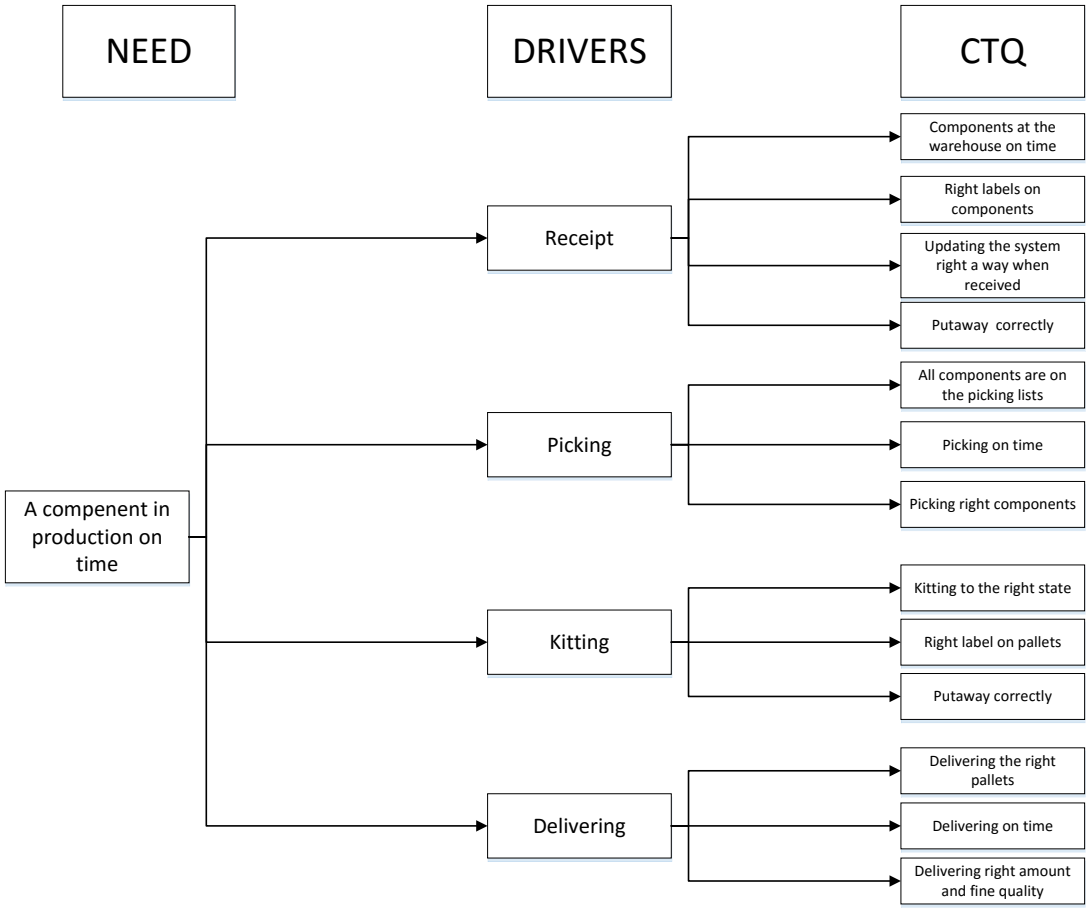

Figure 3. CTQ-tree. (Johansson, 2017)

In this CTQ the need is that Transval needs to deliver items to client's production department on time. It is the main goal for our operating.

Drivers in this process are the four main actions that effects to the result. It all starts when the item arrives to the ILC. It needs to receipted correctly: employee put the information in the system and then does the putaway, meaning he delivers it to the shelf. If either the information in system or the shelf place is wrong, it causes harm on next stage. Next stage is picking. If the pallet is already in wrong shelf place, it may cause the harm that the employee who is picking the item does not notice that it is not the correct item and again it causes harm on next stage. Or even if there is a right item on pallet on right shelf place, the employee may do the mistake and pick from adjacent place. If the employee is not familiar with the look of item, he may even not notice the mistake.

6 MEASUREMENT

6.1 Collecting the data and Pareto analysis

Data was collected in November. In-Factory employees wrote down every mistake, what kind of mistake it was and what was the reason for that. Employees used a form the author has made (Appendix 1). There were very much variety between the days. In one day, there could appear six mistakes and one day there were no mistakes. Every day the mistakes were marked to the Excel (Appendix 2,3) which was a good way to follow the results. After one-month period, it was shown clearly that “lack of item” where the biggest reason for mistakes (Appendix 4). 25 mistakes out of 32 were mistakes where Transval have not delivered the item to production at all. It was clear that this was the problem that need to be solved.

When looking better the “lack of item”-mistakes, it was seen that there were couple of main problems which caused this. There were causes like, item was picked but not delivered, the item was not receipted and because of that it was not in the system, the item was found it the production department already and the biggest reason for first weeks were: did not exist in the Excel (Appendix 5).

6.2 Handling the mistakes

Pareto analysis was made to understand the distribution of mistakes.

In figure 4 it is seen that lack of items were biggest reason for mistakes. Almost 80% of all problems were caused because of this.

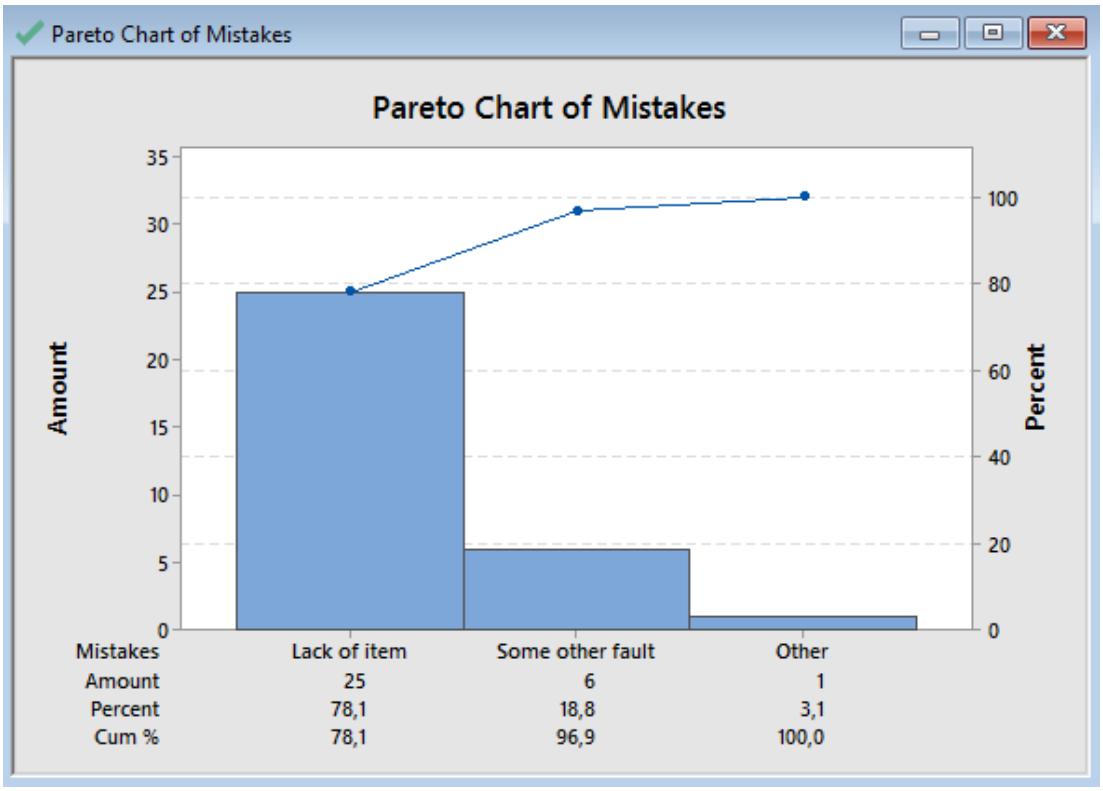

Figure 4. Pareto analysis. (Johansson, 2017)

Next, another Pareto analysis was made to analyze the distribution of missing items. Excel-problems were the biggest reason and fortunately this were eliminated already during the measurement.

Next three biggest reasons were picked but not delivered, not receipted and found from production. Because the limited time of this project, it was decided to focus on these three problems.

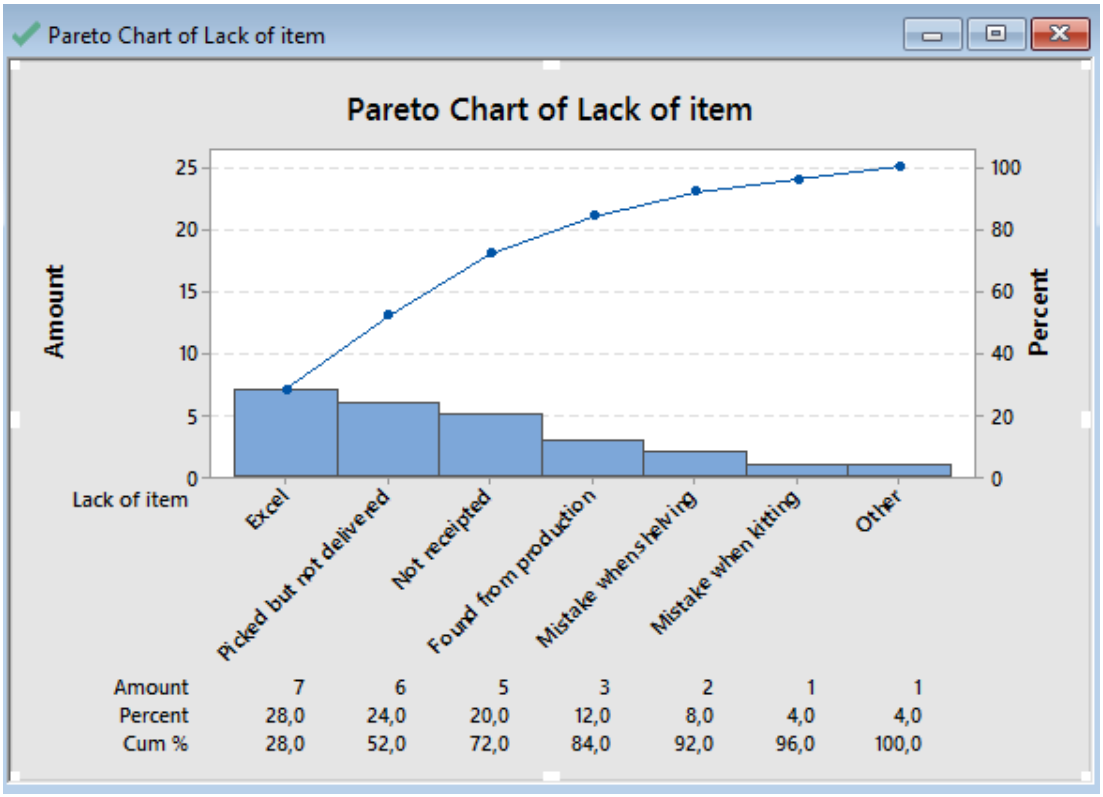

Figure 5. Pareto analysis. (Johansson, 2017)

In the middle of the data collecting process, this Excel problem was already solved. Transval uses an Excel table where they mark every kitting sets they have picked. Meaning: when employees pick items from shelves and make picking sets (of one project) and take photos, they mark those in Excel. When In-Factory employees are starting to deliver items (kitting sets) to production, they scroll out the Excel to find all the necessary kitting sets of that project.

The problem with this Excel was with the login settings. It was possible to use excel in “read-only” status. It means that if someone was using this excel in other computer with other username, some other could open the excel and look it in “read-only” status. In this status the modifying the excel is not possible, or it won’t save it. In many cases some employee closed the warning window that says “read-only” status and wrote down the kitting sets and “saved” the excel and closed it. When it was opened next time, there were no marks of those lines and In-Factory employees did not know they were meant to deliver something else. Luckily this was noticed and setting were

changed so that only one username in one computer could open this excel and everybody are using the same one.

Beside of this Excel problem, there were six other reasons for mistakes. It was decided that three of those will be research more: picked but not delivered, not receipted and found from the production department.

7 ANALYZING THE RESULTS

7.1 Fishbone diagram

Data analyzing started with meeting with the team. Six-person group gathered together to think about the possible facts that affects to the appearing problems. The result was summarized and the fishbone diagram was made to clarify it.

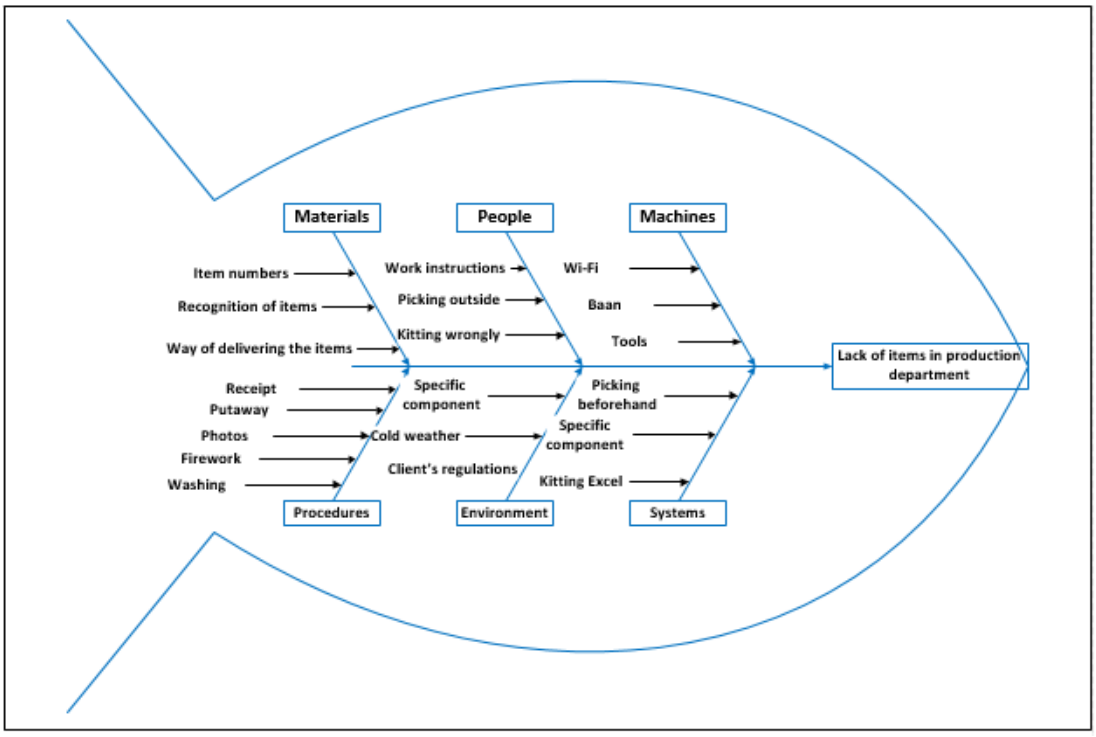

Figure 6. Fishbone diagram. (Johansson, 2017)

7.1.1 Materials

Material issues that might affect the appearing mistakes are that the item numbers of the components are long and complicated, so if one number goes wrong, it changes the whole component. Recognition of items are sometimes hard because the amount of the similar and specific products. Especially for new employees it is hard to know which component is which. Also, the way of how the components arrives to ILC differs a lot. Some of those are in wood boxes and some of those are covered with plastic and one cannot say what component it is without opening the package.

7.1.2 People

For people section, the team mentioned about the work instructions, which should be known for everyone to ensure everybody knows the common way of acting. The outside picking could cause problem as well because those are not in the specific shelf places like component inside are and it is easier for employee to pick the wrong component. Kitting wrongly is one big problem. If the component is placed to wrong kitting station it does not got rightly to the production department.

7.1.3 Machines

Team thought that machines that affects this process are for example Wi-Fi. If it stops working, all the work stops. Everything in the warehouse works with the Wi-Fi and if it is down, so being the systems as well and Transval do not know what they should deliver. Related to this, the computer system Baan is essential to work as well and it needs the Wi-Fi connection. Lastly the tools and equipment need to be fine of course.

7.1.4 Procedures

There are several procedures that are done in the way of component going through the warehouse from receipt to production department. All of those need to work correctly to ensure that the component is on production on time.

7.1.5 Environment

On environment section the working place, west coast harbor, makes the conditions hard sometimes. Cold weather, especially in winter time, with wind and snow makes outside working hard. Components need to be warm and dry when those are delivered to production and some big components need hours of heating inside the warehouse before those can be delivered. Client has also many strict rules and instructions and those forces Transval to work in certain way.

7.1.6 Systems

Last section is systems. It is important to update all the systems when needed to keep in track what is happening. If there are no updates, coworkers do not know some work is already done and it causes mistakes and extra work. Some components are also tricky and are not in the normal system at all.

7.2 Generally

When the excel, problem solved by itself, the other mistakes were needed to be handled. Picked but not delivered was next problem. Together with the team the possible causes were discussed. One thing they have noticed was that there were cases that employees had taken wrong pallet from wrong shelve place. Other problem was that when the items were picked, it should be marked on the other Excel that it is ready to go. Some of these pallets were not in the Excel. Both problems can be handled with good instructions.

Next problem was not receipted correctly. There were couple of main reasons for this. In some cases, the items had arrived to ILC and receipted but the picking was incorrect because the receipt was done wrongly in the system. Or two items were receipted across because the lack of employees' item recognizing skills.

Found from production was third biggest problem. In these cases, the item was lost and client were asking to deliver it immediately and warehouse workers search from

everywhere and were sure that the item is not in the warehouse. In the end, the item was already in the production department but client just did not see it.

7.3 FMEA - Failure Mode and Effect Analysis

FMEA is risk analysis tool. There are two key types used within Six Sigma: product FMEA and process FMEA. Product FMEA analyses the function, design and potential failure of each product. Process FMEA analyses the key outputs and potential failures of each step of a process and consider the effect of process failure on the product or service concerned. (Brook 2010, 106)

In this case, the process FMEA is suitable. First column describes the process, in this case the problems which causes delivering mistakes. Next there are potential failure modes listed. Those are biggest mistakes that appears when considering the delivering mistakes. Then there are potential causes, causes that affects the problems. Next two columns tell the severities and occurrences of each mistakes. The ranking rate variates from very low to very high. High and very high severities are so serious problems that if those appear, it causes immediate actions. Lastly there are controlling and prevention section. There are listed instructions and actions that should be made to improve the work.

Process	Potential Failure Mode	Potential Causes	Occurrence	Severity	Controlling/Prevention
Picked but not delivered	Picked but not marked in Excel	Carelessness actions	L	L	Note on the wall that remindes not update the Excel
	Wrong pallet delivered	Putaway to wrong shelf place	VL	L	Better markings to shelf places
		Picked wrong pallet	VL	L	Better markings to shelf places
Receipt mistakes	Item arrived, receipted but not picked	Picking list does not show item which are not arrived yet.	VL	VL	Foremans should update the picking list more often
		Delivered straight to the prosuction after arriving but system not updated	VL	VL	Remind the employees of updating the systems
	Receipted across	Wrongly recognized item	L	M	Train the employees to recognize the items.
Found from the production department	Item got lost after washing	Not any specific place where to put items after washing	L	VL	Communication with the client
	One shift has moved the item and other did not find it	Lack of communication between shifts	L	VL	Communication with the client

Figure 7. FMEA. (Johansson, 2017)

VL=Very low
L=Low
M=Medium
VH=Very high
H=High

7.3.1 Picked but not delivered

There were two potential failure modes for this problem. First, there was some cases that item was picked but the employee has not marked it the Excel-system. The potential cause for that was usually just carelessness. The occurrence is low and if this happens, it only causes low harm. Controlling act was putting the notes on the wall to remind the employees of updating the Excel.

Second problem was delivering the wrong pallet. The potential causes were putaway to wrong shelf place or picking the wrong pallet. The occurrence for these was very low and the severities low. The solution for avoiding these problems in the future, was better markings to shelf places.

7.3.2 Receipt mistakes

First problem was that item was delivered to ILC and receipted but it was not picked when needed. The potential causes for that were that picking list does not show the item which has not arrived yet, so when the picking has been done, the employee did not know he should pick this item as well. When the item has arrived to ILC, the picking list updates but it may be too late if the employee do not know that. It occurrences very rarely and the harm is also a very low because usually it is noticed soon enough. To avoid this for happening again, the foremen should print the updated lists more often.

Other potential cause was that the item was delivered straight to the production department after it has arrived because of urgent situation and employees forgot to update

the system. This happened very rarely and causes very little problem because the component was on the right place but only the system was mixed. The solution for that is to remind the employees for updating the systems.

Then there was problem where employee had receipted across. Because of badly component recognizing skills, someone marked the component wrongly. It happened with low occurrence but the severity was medium. The solution for that is to train the employees to recognize the items.

7.3.3 Found from the production department

First problem was item got lost after washing because there was no any specific place where to put the component after washing. When the component was just put somewhere in the production, the employees did not found it every time. Occurrence was low and severity very low. The solution is to communicate with client about the possible place.

Second problem was that production department works in two shifts and sometime another shift has moved some component or pallet to some place and the other shift did not found it anymore. Then they thought that Transval has not deliver the components at all and asked us to do so. The occurrence was low and severity was very low, because the component was already in production department. The solution is to ask the client communicate more between their shifts.

7.4 Reliability and validity of the research

Reliability of the research tells how reliable the results are. Practically it means that if some other person test the same issue with same research methods under similar conditions, she or he should be able to get same results again and again.
(Website of Market Research World 2017)

In this case, the result variates a lot between days because the amounts of mistakes are not constant. Still the results should be as reliability each time those are measured.

Validity of research usually answers the question whether the research is measuring what it is supposed to be measuring.
(Website of Market Research World 2017)

This research was case-by-case and the data was quite narrow. Even the data and measuring tools are valid in this case, it does not mean that it would work for some another case.

8 IMPROVEMENTS

8.1 What kind of improvements?

FMEA is good overview about the case. In the last column, there are controlling and prevention methods which are the base of these improvements. First, there will be notes on the walls that reminds employees to update the Excel-system every time they do picking. It has been noticed in this company that if there are text on the wall that everyone can read it several times a day, it stays in mind better. Secondly, there will be better marks on the shelfs. Now there are only marks on the side studs, not on every single beam, and this will be changed so that every shelf place has its own mark. Problem with recognition of components will be solved so that there will be arranged training course by client that employees could learn to recognize the components.

8.2 How to control those in future?

There is an indicator in client's system that measures the mistakes of production delivers. It has not been in use yet but this case showed that it needs to take on use. Employees in Transval and in client production department will be trained to use this indicator. This system asks employees of Transval and client to write down every time something goes wrong with delivering and it measures then automatically how often those appears. There will be still need for manual measuring at the first. The author

will do couple of measurement sessions in the future to see if the indicator is used rightly.

9 SUMMARY AND CONCLUSION

As the conclusion of the study, the theoretical part was learned information from the books, articles, e-books and author's own knowledge about the Lean Six Sigma learned from the Green-Belt studies. The empirical part was based on the theoretical part and the author's own information and experience about the topic learned during the working career in Transval.

To summarize the measurement project, the DMAIC was followed well which made the completing of the project easier. It is seen that when the main problem, incorrectly working Excel-system, was eliminated, the problems and mistakes decreased to half. It was common reason for mistakes that employees were carelessness. Those are luckily quite easy to improve with good instructions and reminders.

The objectives of the study were met as the boundaries of the thesis did not stretch and the research questions were achieved. The idea was to focus only on mistakes and problems that appears when delivering items in production system and ignore the welding department this time and that is what happened.

The research questions asked how much Transval makes mistakes and how they can reduce them and author answered for those questions. Two other questions were about improving the work to avoid this kind of mistakes in future and the results shows that good instructions and training will help Transval to achieve the goal.

10 DISCUSSIONS AND RECOMMENDATIONS

The author thinks that best way to make sure that these new improvements work is to have follow ups four times a year. Those follow ups are planned before hand and the author will gather the data like this time to see if there are still mistakes which appears to harm the working. The indicator in client's system will hopefully start working and it makes it easier in the future to follow up the performance.

Self-assessment

The author works full-time in Transval and trained herself as a Green-Belt professional in autumn 2016. This inspired her to use Lean Sig Sigma in the thesis. When she asked if the company had any need for thesis, this topic came up. The thesis was done between November 2016 and spring 2017. The author thinks that collecting the data was one of the difficult parts because she could not be in the place all the time to make sure she got all the data. After the data was collected, it was only about her time schedule to write it down. Finding the time to read for the theoretical part and to write the thesis was sometimes problematic, because she worked 40h/week in Transval and same time studied full-time in Satakunta university of applied science. Moreover, the author is satisfied with the result and likes to thank the working team for the help and the supervisor of her, Toni Jokela, for the flexibility in work place.

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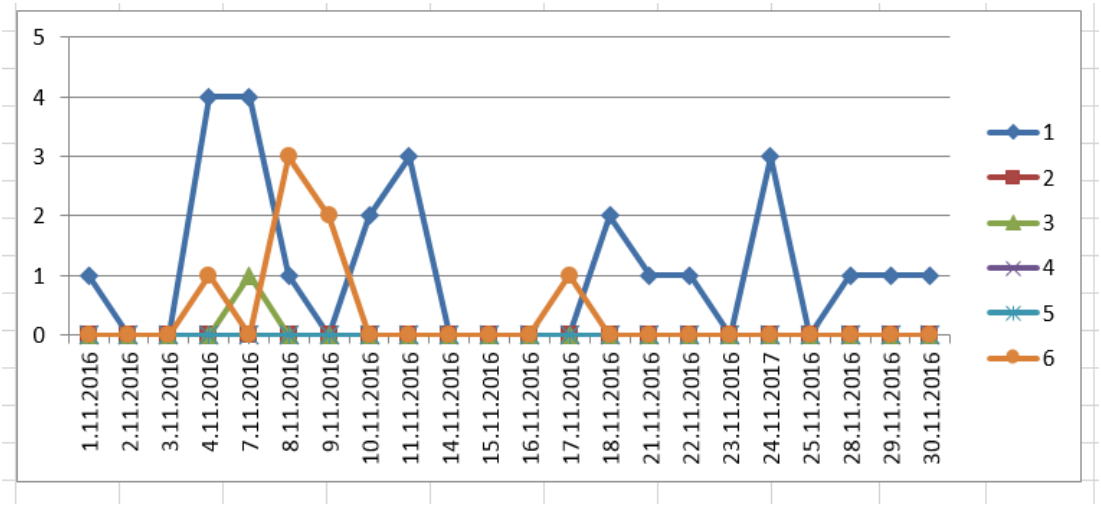
APPENDIX 1

Päivämäärä (date)			
Aloitusaika (starting time)			
Miten ilmoitettiin (how the notification came)			
Mitä hukassa (what is missing)			
Mistä löytyi (where it found from)			
Syy (reason, if known)			
Lopetusaika (closing time)			

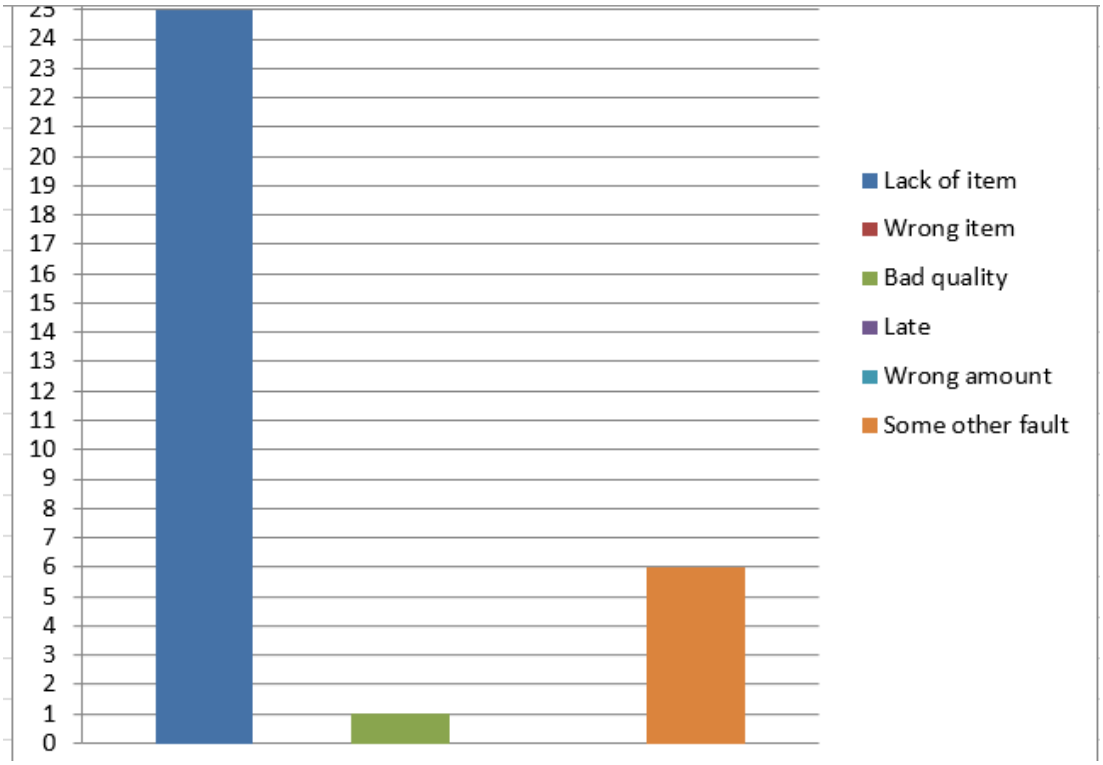
APPENDIX 2

	Mistakes when delivering to production							
		1.11.2016	2.11.2016	3.11.2016	4.11.2016	7.11.2016	8.11.2016	9.11.2016
I	Lack of item	1	0	0	4	4	1	0
II	Wrong item	0	0	0	0	0	0	0
III	Bad quality	0	0	0	0	1	0	0
IV	Late	0	0	0	0	0	0	0
V	Wrong amount	0	0	0	0	0	0	0
VI	Some other fault	0	0	0	1	0	3	2

APPENDIX 3



APPENDIX 4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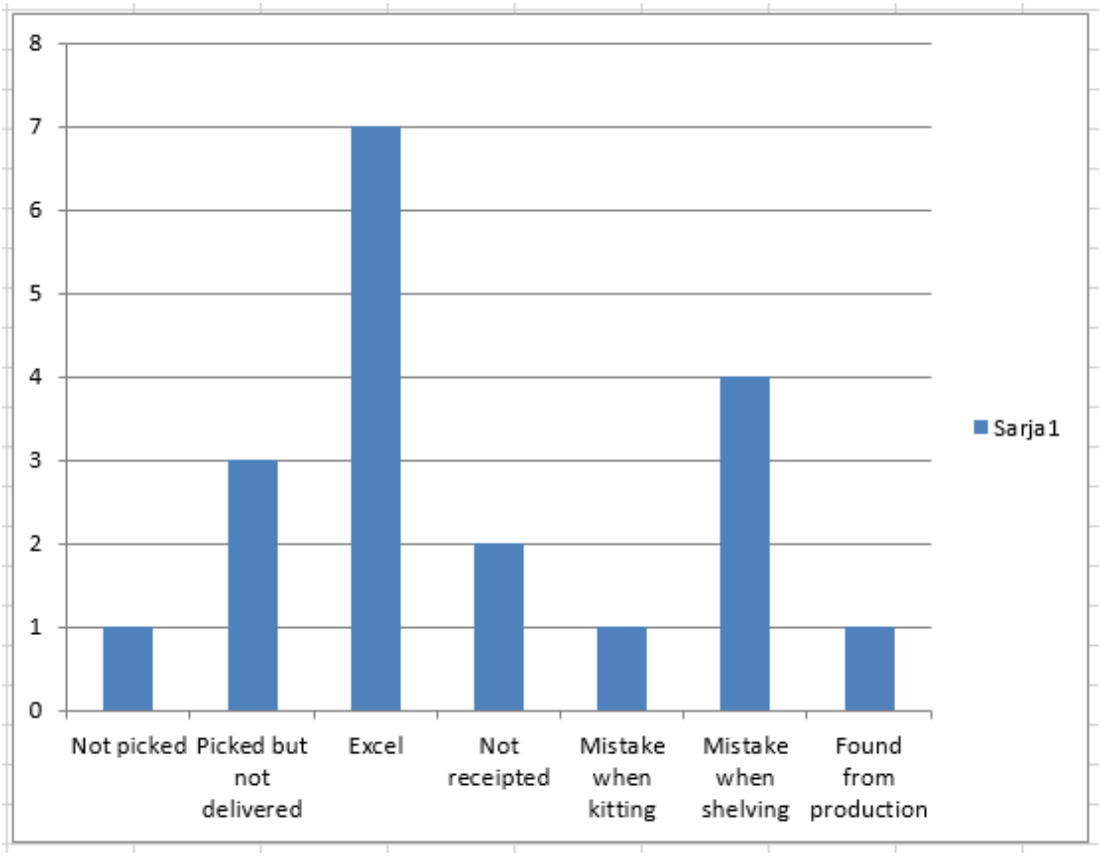
12
11
10
9
8
7
6
5
4
3
2
1
0
Lack of item
Wrong item
Bad quality
Late
Wrong amount
Some other fault

APPENDIX 5


8
7
6
5
4
3
2
1
0
Not picked
Picked but not delivered
Excel
Not receipted
Mistake when kitting
Mistake when shelving
Found from production
Sarja1