UNIVERSITY OF VAASA

FACULTY OF TECHNOLOGY

INDUSTRIAL MANAGEMENT

Ari Mäkelä

SUPPLIER QUALITY FROM REACTIVE TO PROACTIVE

Master's Thesis in

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FOREWORD

Quality is an interesting topic and it has strong links to all areas in industrial management. Quality should be embedded to all aspects of your work regardless to what we do for living. For me having a background in engineering and purchasing I see endless possibilities to use of qualitative methods and theories that can be easily applied to our daily work. In the past decade Finland has been able to compete in the global markets in mechanical industry with quality not cost. I hope that focus on quality will continue strengthen in future as well.

I would like thank my superior and mentor Ari Poutanen from the case company for giving me the possibility to complete my second degree while working in his organisation.

I also want to thank Petri Helo from the Faculty of Technology, University of Vaasa for supporting me and understanding circumstances around my thesis while working in a timely demanding position in a newly established organisation.

Vaasa, 14.5.2015

Ari Mäkelä

SYMBOLS AND TERMS

SQA	Supplier Quality Assurance
SQE	Supplier Quality Engineers
SQV	Supplier Quality Verification
PQA	Production Quality Assurance
SM	Supply Management
SDE	Supplier Development Engineer
SP	Strategic Purchaser
OP	Operative Purchaser/Purchasing
SAP ERP	SAP enterprise resource planning. SAP is a software to manage business operations and customer relations.
NC	Non-Conformity
NC Claim	a Non-Conformity claim (for supplier)
Resolution owner	Responsible for NC claim management (opening and closing)

Task (NC Claim task): Individual tasks assigned to responsible persons in SAP

QE notification:	Supplier non-conformity found in production by PQA
QV notification:	Supplier non-conformity found in Supplier Quality Verification (incoming inspection)
TQM	Total Quality Management
TQC	Total Quality Control
TPmgt	Total Productivity Management

UNIVERSITY OF VAASA

Faculty of technology

Author:	Ari Mäkelä
Topic of Master's Thesis:	Supplier Quality from Reactive to Proactive
Instructor:	Petri Helo
Degree:	Master of Science
Major:	Industrial Management
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ABSTRACT:

Goal of this study is how the supplier quality assurance organization can move from reactive to proactive way of working. An organizational change inside the case company is the starting point for this study.

As the researcher is working in the organization during the study period an action analytical research method is chosen. Case study approach is chosen as the researcher is inside the organization and observes the current situation in contrast to existing practices and guidelines while applying chosen theories to achieve given targets.

In this study a strategy is created for the supplier quality assurance department. From strategy a development plan is induced. Development plan includes consideration on responsibilities and communication on non-conformity handling in the case company. For the incoming inspection workshop methods to reduce lead time are done in a form of layout development project. Performance measurement indicators are created to adjust and confirm the effectiveness of several on-going development projects. Few main points for further development are given for the management to consider.

This study gives an overall picture of a one way to establish a new strategy and initiate needed development projects to meet the productivity targets given by company's management.

KEYWORDS: Supplier quality assurance, performance measurement, strategy

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Teknillinen Tiedekunta

Tekijä: Ari Mäkelä

Tutkielman nimi: Toimittajalaadun kehittäminen

Ohjaajan nimi: Petri Helo

Tutkinto: Kauppatieteiden maisteri

Ohjelma: Tuotantotalouden maisterikoulutusohjelma

Pääaine: Tuotantotalous

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TIIVISTELMÄ:

Tämän tutkimuksen tavoitteena on tutkia miten toimittajalaadunvarmistus voi siirtyä reaktiivisesta reagoinnista ongelmien proaktiiviseen käsittelyyn. Tutkitussa yrityksessä tehty organisaation muutos toimi tämän tutkimuksen aloittavana tekijänä.

Tutkija työskentelee case-yrityksen osastolla tutkimuksen ajan, seuraten tutkimusotetta läheltä ja osallistuen samalla tutkimuksen ilmiökenttään. Menetelmäksi valittiin seurantatutkimus, toiminta-analyyttinen tutkimusote. Case-tutkimuksessa perehdytään olemassa oleviin toimintatapoihin, sääntöihin ja ohjeisiin. Tutkija pyrkii sovittamaan teorioita tähän kehykseen, jotta saavutettaisiin annetut tutkimuksen tavoitteet.

Tutkimuksessa luodaan strategia toimittajalaadun varmistusosastolle. Strategiasta johdetaan kehitysohjelma, jolla pyritään saavuttamaan tutkimukselle annetut tavoitteet. Kehityssuunnitelmassa otetaan kantaa osaston ja yrityksen sisäiseen vastuun jakoon, laaduttomuuksien hallintaprosessin kehittämiseen ja kommunikaation parantamiseen. Vastaanottopuolen laadunvarmistuksen osalta laaditaan kehityssuunnitelma verstaan kehittämiseksi ja kiertonopeuden parantamiseksi. Tutkimuksessa kehitetään tavoitteisiin liittyvät mittarit, joilla voidaan seurata projektien tehokkuutta ja sitä, miten tavoitteisiin päästään. Jatkokehitysehdotukset listataan yrityksen johdon käytettäväksi.

Tutkimus antaa yhden ehdotelman siitä, miten strategian avulla voidaan kehittää yksittäisen osaston toimintaa ja miten varmistetaan projektien onnistuminen suhteessa johdon asettamiin tavoitteisiin.

AVAINSANAT: Toimittaja laadun varmistus, Toiminnan mittarointi, Strategia

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1 INTRODUCTION

Concept of total quality management is a philosophy where important role is reserved for purchasing. Quality of the end product is determined by the quality of the purchased components, purchased sub-assemblies and raw materials. Quality should be developed also in the supplier level. This is why many manufacturers have implemented (SQA) Supplier Quality Assurance functions. (Van Weele 2005:195.)

Concept of quality assurance is:

"Implementation of appropriate system of predetermined and systematic requirements designed to create confidence that the quality required shall be achieved." (Perigord 1990: 21).

Deming (1986:3) refers to *Walter A. Shewarts book Economic Control of Quality of Manufactured product* in Figure 1. He suggest that improving quality has multiple effects on company's success. Quality is considered as a starting point for any company's main goals. This was widely used in Japan as early as 1950's.

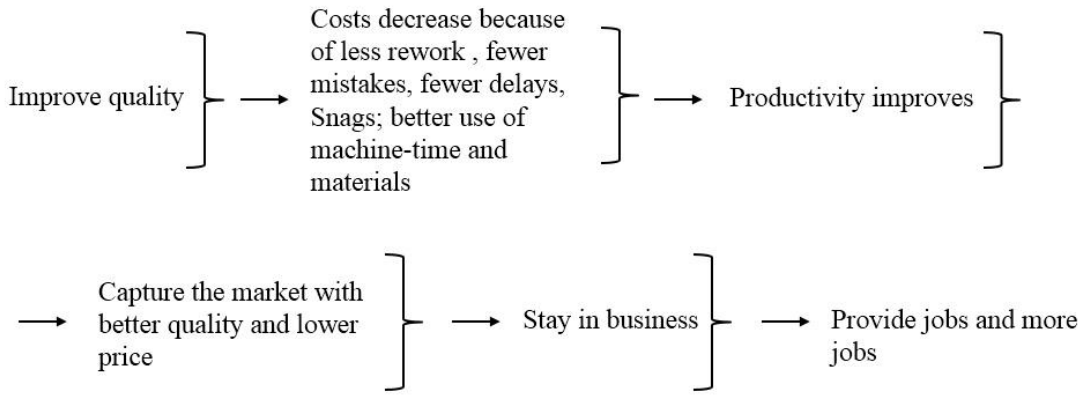


Figure 1: Improved Quality Chain Reaction (Deming, 1986).

Quality is not a marketing determination, it's not an engineer's determination or management's determination it is a customer's determination (Feigenbaum 1991:7). From this we can conclude that quality plays a big role in any company's business.

1.1 Purpose of the study

In the end of 2013 an organisational change was conducted in the case company. This was a strategic decision that separated supplier quality assurance from quality department and moved it under the operational purchasing department. Due to hard competition in case company's industrial sector more customizing is being done to the produced products. This increases the variety of sourced components, design lead times and creates situation were supplier non-conformity cases are rising. Case company creates annually ~2500 non-conformity claims to ~200 individual suppliers. This increases the workload and quality costs. Costs rise when non-conformity claim handling lead times growing longer as more work is needed to monitor the process. Reduction of non-conformity handling lead times is seen as a critical step to improve quality. Quality has risen as competitive advantage as available capacity on the markets is larger than demand. This case study was conducted based on the initiative from operational purchasing management.

Reasons for this were that we wanted to:

- Improve supplier quality assurance
- Improve communication and cooperation with suppliers
- Map supplier quality costs
- Move supplier quality from reactive towards a proactive way of working
- Clear responsibilities between case company and supplier
- Implement and improve utilization of LEAN in supplier quality assurance

According to Van Weele (2005:243) internal changes occur when company begins to rethink their primary processes and their supplier relations in contrast to whole value chain. Van Weele (2005:245) has taken one example of revised purchasing organisational structure in his book. In this example supplier quality assurance has been added in to the purchasing organisation.

1.2 Research questions and objectives of the study

In Cooperation whit the company's management team following research questions were drafted. The target of the study is to understand and carry out actions that will enable reaching given objectives and answer to given research questions. The research questions are linked to reasons why the organisational change was conducted in the case company.

Research questions:

- *How can we speed up the non-conformity process?*
- *How can we identify worst performing suppliers?*
- *How can we reduce the supplier quality verification/ incoming inspection lead-time?*
- *How can we reduce the amount of open supplier quality non-conformity claims?*

In relation to research questions following objectives were given to newly established department:

- *Identify and categorise supplier base according to produced quality*
- *Reduce non-conformity Claim lead-time by -50%*
- *Reduce Supplier Quality Verification/Incoming inspection lead-time by -60%*

1.3 Definition/Scope of the study

- Case company unit's direct purchased goods.
- Only directly to produced components purchased components. Excluding indirect materials.
- Component quality non-conformities within the company that are related to supplier quality (QE/QV notifications).
- Internal quality and field customer issues are excluded.
- Only non-conformities were SQA department is resolution owner.

1.4 Structure of the thesis

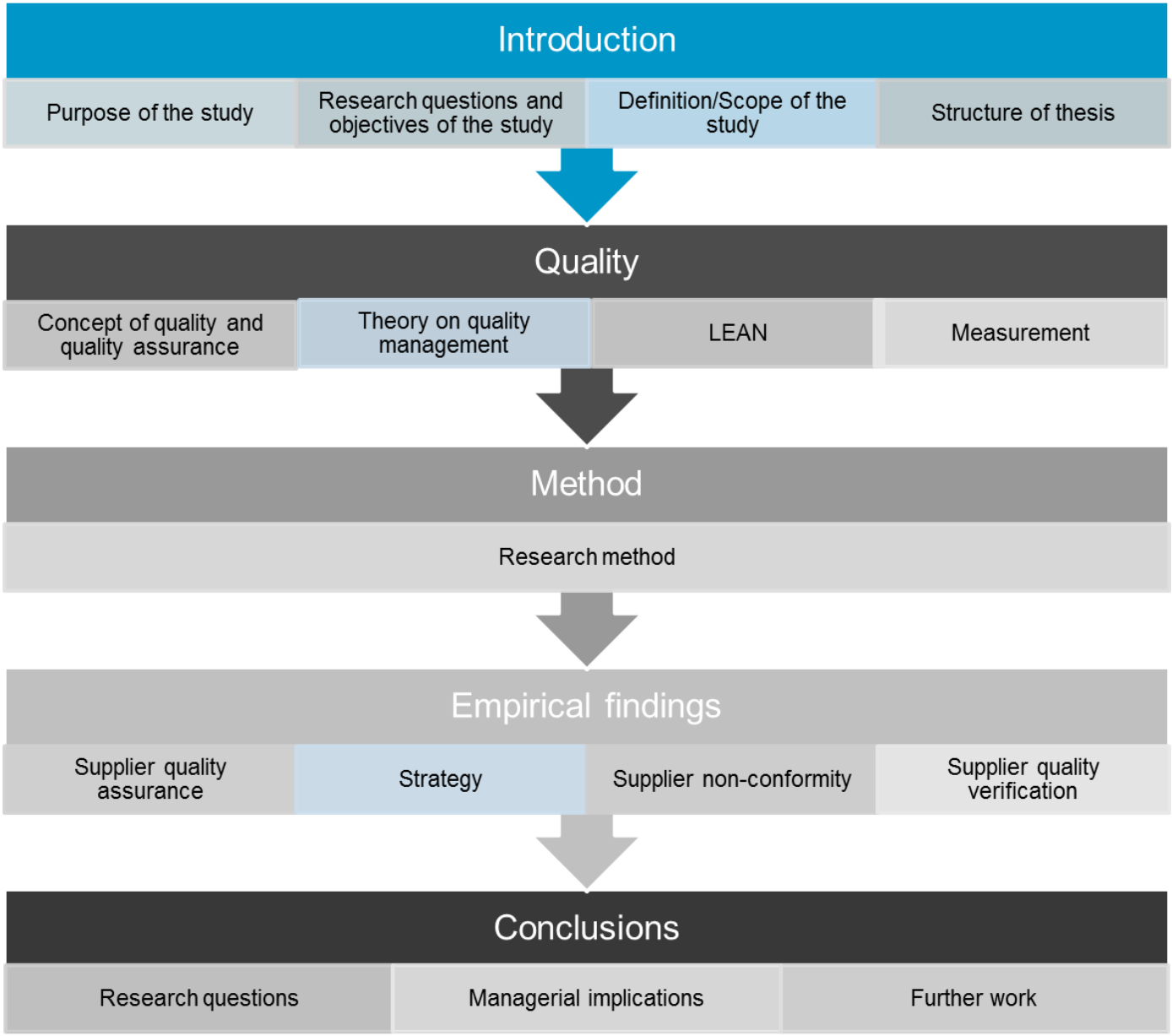


Figure 2: Structure of the thesis.

2 QUALITY

Purpose of this chapter is present quality theories used in this study. This chapter includes short review on most common concepts of quality, quality management and quality assurance.

2.1 Concept of quality

Concept of quality has many interpretations depending on what angle the quality is considered. Fulfilling customer needs in the best possible way is common concept while it's being done in a profitable and efficient way from the company's point of view. (Lecklin 2002:18.) Juran (1988:2.2) defines two meanings that dominate the concept of quality:

> "1. Quality consist of those product features which meet the need of customers and thereby provide product satisfaction.
>
> 2. Quality consists of freedom from deficiencies." (Juran 1988: 2.2).

To open the Juran's (1988: 2.2) 2 quality meanings we need to understand the concepts used.

Product. Output of any existing process is "product". Usually this refers to services and goods. Services are work performed for someone who requests it and products are concrete physical things like engine of a car.

Product feature. Feature is something that is needed to satisfy certain needs of the customer. Feature can be technological like power of the engine or have other forms such as reliability of the delivery.

Customer and customer needs. Customer can be internal or external. Customer is the recipient of the product. Internal customers are inside the company and external customers are not members of the company. In all cases customers have needs that need to be met.

Product satisfaction. Features on a product that are requested by the customer create product satisfaction.

Product deficiency. Deficiencies in a product can be failure of the product, late delivery, rework or scrap. These deficiencies create problems for the customers. Deficiency can be in a process or in a product. (Juran 1988:2.2-2.3.)

"Quality is free. It's not a gift, but it is free. Nonconformities cost and that we do not do things right the first time." (Crosby 1985:1).

2.2 Deming quality philosophy

Deming had a huge part on quality and productivity management improvements done in Japan. Quality management was utilised as tool to improve overall performance of the company (Lecklin 2002:17). Deming created a system of profound knowledge and following 14 key principles for management to improve.

2.2.1 Deming's system of profound knowledge

According to Deming (1993:94) current management needs to revise their way of managing. To do this profound knowledge is needed. System of profound knowledge provides a theory and a map by which can be organisations understood and optimised. (Deming 1993:94).

Deming's (1993:96) System of profound knowledge consist of four part that are all related to each other:

- Appreciation of the system
- Knowledge about variation
- Theory of knowledge
- Psychology

Appreciation of the system depicts the way how system and process goals are associated with each other. A system cannot exist without a goal that it is trying to accomplish. Management needs to be aware how the system works and how changes in it affect the output of the system. (Deming 1993:98-99.)

Knowledge about variation describes that variation is all around us. Variation is in processes, services and products. To utilize measured data and performance of the people one must have a profound understanding of appearing variances in the system. (Deming 1993:101,103.)

Theory of knowledge acknowledges that management is in any prediction. Theory is a building block of knowledge. Observations of the past gives us a base for a prediction to which we can compare the expected outcome of our statement that our knowledge conveys. Every theory can be revised and extended when taking in to account comparison of prediction with observation of the theory. If no theory exists there is nothing to learn and revise. (Deming 1993:105.)

Psychology helps us to understand interaction between people, interaction between supplier and customer, interaction between manager and his staff and any management system. Manager needs to understand that people are different and utilize this knowledge by using each person's individual skills to the fullest. (Deming 1993:110-111.)

2.2.2 Deming's 14 points to management

Deming developed the 14 points to help companies' management to implement and adopt ways to transform the way of working inside the company. This enabled the company to stay in the business and continue to create value for investors and continue to employ its employees. (Deming 1986:23.)

14 points to management:

1. Create constancy of purpose for improvement of product and service

Products and services should be constantly improved. Continuous improvement is a key factor for company's long-term success. Focus on quality will reduce need for rework, improve profitability and enable employment. (Deming 1986:24.) Top management's

commitment to continuous development is critical. Creating fate in the company's future is important for continuous development working environment to be able exist. (Deming 1986:25.) Focus on education and research is required to secure employees contribution to productivity and quality. This can be achieved by stating constancy of purpose that is the company's goal to provide quality products and continue to have a share in the market by doing so. Focus should put on training personnel, effective supervision of the work and top management's commitment to current work situation at hand. (Deming 1986:26.)

2. Adopt the new philosophy

We need to abandon ineffective management philosophies and adopt new more effective ways to manage quality. We need to question old way of working and not accept any quality deviations in the process. Mistakes and delays in process create costs. High quality and less deviations in the process will reduce costs. (Deming 1986:26-27.)

3. Cease dependence on mass inspection

100% incoming inspections indicate that design of product is not capable to meet the quality requirements. This same as planning for failure. Inspection is expensive and ineffective. The further in to the process the quality defect is discovered the more costly it is. Quality defect should be already identified at supplier's premises. When the product leaves the suppliers premises no amount of inspection will not improve its quality. Inspection work does not improve quality in any way. (Deming 1986:28-29.) If quality is thought to be developed by adding incoming inspection it will only create more rework, scrap and costs.

- Inspection is too late for improving or guaranteeing quality of a product.
- Mass inspections do not guarantee quality and it is ineffective and costly.
- Statistical control is required for inspectors. Repeating tasks create unreliable results due to boredom. (Deming 1986:29.)

Sample inspections on defined statistical way can be useful on improving quality when compared together with suppliers own documentation. It's vital that results are understood at the same way at the supplier and at the customer. Communication on

inspection results can improve product quality and get supplier and customer's quality control on the same page. (Deming 1986:30.)

4. End the practice of awarding business on the basis of price tag alone

Supplier quality needs to be understood in a context with the purchased price. Outsourcing of components need to be based on quality not only on cost. Often price has too big significance in making sourcing decisions. Efficient methods of grading supplier's quality need to in place for cost-effective sourcing decision can be made. Sourcing should focus on reducing cost of production (e.g. cost/hour) not just the component price. Focus should be aimed at the lowest total cost not just the initial component cost. (Deming 1986:32-33.) Usability and requirements of the component to be used in an installation need to be understood by the sourcing and supplier. What in design is critical for the part to fit? Small deviation can have dramatic consequences when the relation to installation and other parts is not understood. Here collaboration together with supplier is important. A company should strive towards having long-term relationships with its supplier. Long-term relations create trust and volition for the supplier to develop and expect more continuum of business relation in the future. (Deming 1986:34-35.) Dual sourcing that is used for protection purposes if the worst case scenario puts current supplier out of the market is a costly policy. Lowest inventory and investment can be achieved by single source. This is a position that every supplier should strive towards. (Deming 1986:36.) Qualification of vendors should not be based on customer ranking measured against customers own internal quality manuals and qualification teams. Supplier itself should aim at being the single source for given component. Customer should even consider budgeting quality training costs performed at supplier. Money spend for training at supplier can have bigger impact than utilising the same amount inside company. (Deming 1986:39-40.)

5. Improve constantly and forever the system of production and service

Continuous improvements need to be done in every aspects of the business processes. Just focusing on product design quality is not enough. Approach to all process development should be proactive not reactive. (Deming 1986:49.) Firefighting with process problems in production is not development. Removing waste and bottlenecks that

create firefighting on the other hand is. To understand what is causing faults in the process the process itself need to be in statistical control. This will allow you to understand the deviations in the process. (Deming 1986:51-52.)

6. Institute training

Training should be available on all levels from top management to shop floor. Top management should be aware of shop floor level training needs that can cause situations where the worker is unable to carry out his tasks. Commitment to training need to start from the top management. Focus should also be targeted at training of new employees. (Deming 1986:52.) Companies often fail to utilize their employee's full-potential. Just setting up training courses is not enough. Training should be tightly linked to employee's current work and customer needs. This way if other negative inhibitors in the work are removed it can have positive outcome on performance. (Deming 1986:53.)

7. Adopt and institute leadership

Leadership is not supervision. Management's job is to lead. Management need to constantly focus on ways to develop process quality. Management should not only focus on meeting given measurable quotas but making sure that these are really achievable. Managers need to be leaders and enablers. Communication whit in the organisation needs to be working. Removing obstacles in the daily work should be a priority and escalation of issues to top management functioning. (Deming 1986:54.)

8. Drive out fear

Fear in organisation creates insecurity and mistrust towards management. Feelings of insecurity on own job can create an atmosphere where employees can try to be as invisible as possible to avoid being detected of making poor quality or performance. This decreases the performance of the employee. Lack of communication between employees and management creates mistrust. (Deming 1986:60-61.)

9. Break down barriers between staff areas

Company should acquire view on the big picture of the supply chain starting from R&D, sourcing and all the way to the workshop floor. Management needs to have the general view what are the problems between different departments and actively try to bring down

these issues. In companies were departments that are tightly organised is a big risk of sub optimizing. Sub optimizing department performance does not usually support the company's common goal. (Deming 1986:62-63.) Communication between different departments is important. Each department should know how their work is linked and affecting the production output. Understanding the manufacturing requirements should be clear already in the design phase. (Deming 1986:63-64.) Deming (1986:64) has criticized that design engineers should get to the factory floor to see and understood the limitations and difficulties that production faces.

10. Eliminate slogans, exhortations, and targets for the workforce

According to Deming (1986:69) Quality is in the hands of the management and the responsibility cannot be hand off to production workers. Posters and sings that emphasize "zero defects" and "do it right the first time" are useless if they are not accompanied by a clear plan how these target will be achieved and how the actual process will be improved. (Deming 1986:66.)

11. Eliminate numerical quotas for management and workforce

Numerical quotas are usually based on estimates done by management and controllers. Management might not always a realistic view on the department's situation. Setting right targets is challenging. If the target is unreachable the end result is dissatisfaction and poor performance because workers feel they will never be able to reach it. Why even try? If on the other hand the target is low. Employees will stop working after the target is met that will in the end create loss of resources for the company. Wrongly set targets can be highly reduce the motivation of the workers. (Deming 1986:69-71.) For management meeting numerical quotas requires a clear plan how these given targets will be met. A manager should not focus only on the process outcome but more on what is done inside the process. Manager should lead the work not supervise it. Manager needs to understand internal- and external customer needs and what is causing the department not to be able to meet them. A development plan should be done based on the observations. (Deming 1986:75-76.)

12. Remove barriers that rob people of the pride of workmanship

Workers should be able to be proud of their work. Management is responsible for making a fear free work environment for all. Clear goals and standards of working environment such that it support quality and productivity. Management has responsibility to communicate given targets and what is done to meet them. Tools and working conditions need to be such state it makes meeting targets possible. (Deming 1986:77-79.)

13. Encourage education and self-improvement for everyone

Management should offer and maintain a constant environment of learning in the organisation. Workforce will sew investments on training as investment on them self. (Deming 1986:86.)

14. Take action to accomplish the transformation

Management needs to agree how they will adopt the previous 14 steps. Responsibility of making the new philosophy work is main responsibility of management. Management is responsible on involving all in this new way of working. (Deming 1986:86.)

2.3 Total Quality Control and Management

In competitive industry any company's goal is when quality is considered to provide services and products into which quality is build, designed, maintained and marketed in the most efficient way possible while meeting the customer expectations. To achieve this goal "total quality control" needs to be achieved. (Feigenbaum 1991:5.)

"Total quality control is an effective system for integrating the quality development, quality maintenance, and quality improvement efforts of the various groups in an organisation so as to enable marketing, engineering, production and service at the most economical levels which allow for full customer satisfaction." (Feigenbaum 1991:6).

To meet industrial quality goals the procedure is called "control". These procedures are done to meet cost and production targets. Feigenbaum (1991:10) states that there are four steps to achieve such a control.

1. Setting standards. For the product there needs to be determined standards that indicate required reliability, safety, performance and cost quality.

2. Appraising conformance. Conformance of manufactured products need to be compared with the given standards.
3. Acting when necessary. Problems and their causes need to be addressed when they can affect customer's satisfaction on the product.
4. Planning for improvements. Continuous development is needed in order to improve reliability, safety, cost and performance standards. (Feigenbaum 1991:10.)

For successful management effective control is a must. Failing in the control means loss of revenue and increased costs for the company. Losing control has also a vital part in decreased product safety and liability. (Feigenbaum 1991:10.)

One of the principal engineering and managerial strengths in a company is the powerful total quality control capability. Total quality management consists of the full lifecycle of a service or product from design to customer service. (Feigenbaum 1991:14.) Van Weele (2015:201) states that implementing total quality management requires major adjustments in systems, structure and communication patterns. This is also applicable to the purchasing department that wants to create a specific policy concerning supplier quality assurance.

As total quality management has proven to grow during the 1990's even more popular than before as it includes the same basic principles as total quality control, quality assurance, and company-wide quality control. When quality and continuous improvement is a key part of all organisational functions in a company it implicates that every employee is responsible for carrying out these quality tasks in their daily work. From TQM perspective quality is the most important issue for any company (Russell & Taylor 1998:85.)

2.4 Total Productivity management (TPmgt)

"Total Productivity Management (TPmgt) is a proactive, pragmatic, innovative, and unique concept, management philosophy, and systematic process, based on a integration of industrial engineering and behavioural sciences. "(Sumanth 1998:23).

If a company is able to increase its total productivity this transcends in to improved product quality and service quality, production costs will decrease and profit and market share will be improved. If management takes on as one of its main tasks to improve the total productivity it will also attain several other goals as a result. These other goals are innovation, market share, efficiency, effectiveness, profitability, stability, social welfare and growth. (Sumanth 1998:24.25,)

Sumanth's (1998: 63-64) Total productivity perspective is the basis for TPmgt, which is based on the productivity cycle (Figure 3).

Sumanth's (1998: 63) Total productivity Cycle:

- Measurement (M)
- Evaluation (E)
- Planning (P)
- Improvement (I)

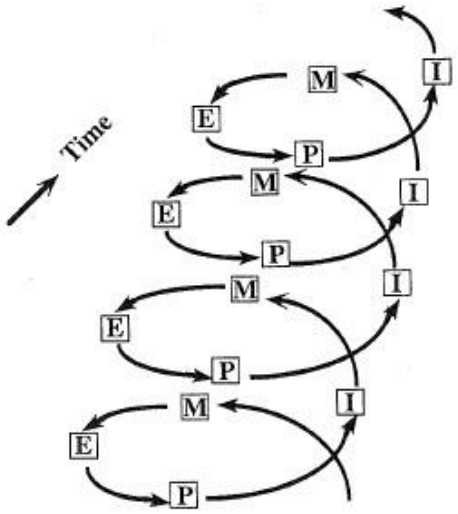


Figure 3. The Productivity spiral (Sumanth, 1998).

Concept of productivity cycle seems to be two dimensional, but it is in fact three dimensional when time is included. (Sumanth 1998:63.) For a company the first step is to start measure productivity. All improvements in total quality perspective are driven forward by measurement system that is based on measuring total productivity. (Sumanth 1998:65.) Second step for a company is to evaluate the productivity. In this phase planning and measurement are combined. Productivity evaluation is comparison between general productivity situation and taken time period used as reference. (Sumanth 1998:86.) Third step is planning. Targets for productivity are established in this phase. These planned targets can be used as reference points in "evaluation" phase of the productivity cycle. It needs to be noted that planning for productivity improvement and productivity planning are not same thing. (Sumanth 1998:89.) The fourth phase is the productivity improvement. TPmgt includes about 70 different techniques how to improve total productivity. These are described in Appendix 1. (Sumanth 1998:93-94.)

In Figure 4 Sumanth (1998:308) describes the evolution of the quality management. From the inspection to total quality management and finally total productivity management. Sumanth (1998 306-307) claims that TPmgt includes possibility utilize all TQM and re-engineering methods available.

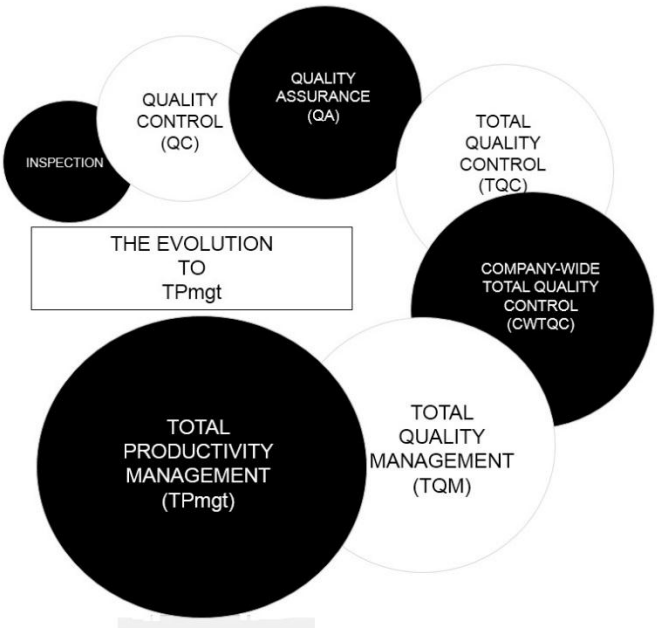


Figure 4: Evolution of TPmgt. (Sumanth 1998).

2.5 Lean manufacturing

The first thing when it comes to understanding Lean is the concept of *muda*. *Muda* means "waste" in Japanese. Waste is inside every manufacturing process. It's unnecessary work, movement, repair, waiting or warehousing. The counteracting force against *Muda* is Lean Thinking. Concept of value is tightly linked to *muda*. Value is the part of the process that is expected by the customer, it's the part that adds value to the product. When waste or muda is removed from the process the value added is maximised. Lean is about doing more with lesser resources. Lean manufacturing means reducing work, production and workspace, waiting times again and again to achieve a lean process where value added is maximised and waste reduced to minimum. (Womack, Jones: 1996:15.)

Specifying value is the starting point of any Lean manufacturing process. Customer is the only one who define what is value to them. For the company in manufacturing business this means that concept of value needs to be tightly linked to the design of the product. Understanding this link is vital in efforts of chasing the Lean manufacturing process. (Womack, Jones: 1996:16-19.)

Second step on the path towards Lean manufacturing is identifying the value stream. Value stream consist of process steps that are needed to produce the product according to customer requirements. Transparency in the process is important in understanding the process and its individual steps. All the participants in the manufacturing process need to be aware how their input is affecting the total output of the process. This enables employees and managers to tackle the revealed waste in the process. (Womack, Jones: 1996:19-21.) According to Womack and Jones (1996:19-20) Process has three types of steps in them:

1. Process steps that add value.
2. Process steps that do not add any value but are unavoidable.
3. Process steps that do not add any value.

Goal of the company is to remove all process steps that do not add any value, minimize the mandatory and unavoidable steps so that value adding steps will have a bigger part of

total manufacturing process. Lean manufacturing is a process of constantly analysing the process to find waste and remove it. (Womack, Jones: 1996:20-21.)

Third step is creating Flow. When the biggest waste creating steps are removed from the process the next step is to create flow to the process. Value adding steps of the process should have flow. One of the best examples of flow is Henry Ford's T-model production line where the effort and process steps of producing a car was reduced by 90% by simply lining the production in to a process where each step followed the production sequence of a T-model. Ford created flow to the process by eliminating unwanted movements and production steps. This kind of total re-arrangement of process is called *Kaikaku*. Other continuous improvement method in Lean is *Kaizen*. Kaizen translates to incremental and continuous development of the process (Womack, Jones: 1996:22-23.) Creating flow means that management needs to look over the department barriers and understand the total process. There should be no holy processes and organisational responsibilities in a company. A lean manufacturing company needs to be able to rethink the production value stream and create flow over individual department and responsibility barriers. (Womack, Jones: 1996:24.)

Fourth steps is implementing pull. When you as company are able to reduce the lead time of the sales, design, purchasing and production it means that you are able to answer to customer needs faster. Faster means better customer satisfaction. This indicates that you can reduce your costs by producing the goods based on the customer's needs rather than stocking up your products and offering them only limited amount of specifications. Meeting customer needs and reduced lead times mean increase in sales. Pull means that customer are requiring the product from you rather than you pushing them your limited inventory with predefined specifications. (Womack, Jones: 1996:24-25.)

Last step is perfection. To achieve perfection a transformation in the people needs to take place. People need to see that Lean is not a project, it is a continuous improvement process. Perfection means transparency in the whole production chain where feedback is given immediately. (Womack, Jones: 1996:25-26.)

2.5.1 LEAN 5S

5S is simple 5-step way of increasing safety, quality and productivity in the workplace. 5S is based on visual demonstration of the improvements. Five steps of 5S are: Sort, Set, Shine, Standardize and Sustain. (Case Company 2012.)

- Sort: Sort out necessary and unnecessary items. Goal is have easy access to necessary items by eliminating the unnecessary.
- Set: Set a location for each item. Goal is to have a place for everything and everything is in its place
- Shine: Shine, Clean and polish. Goal is to remove dirt, maintain tidiness and have equipment in in top condition.
- Standardize: Standardize 5S activities. Goal is to maintain the 5S practices as a standard. Standardization is a base for further improvements.
- Sustain: Sustain and make 5S a way of life. Goal is that 5S is no longer an event but a routine that enhances the overall performance within the case company.

Concept of 5S is based on regular measurement and audit of 5S level of the organisation and individual departments. (Case Company 2012.)

2.5.2 Quality control cycles

Ishikawa (1990:37) has developed the “Deming Cycle” that consists of concept of Plan, Do, Check, Act (Figure 5). Ishikawa’s (1990:38) PDCA cycle includes 4 steps.

1. Choose objective
2. Plan related actions and methods to be used.
3. Do the work and check results
4. Initiate corrective actions.

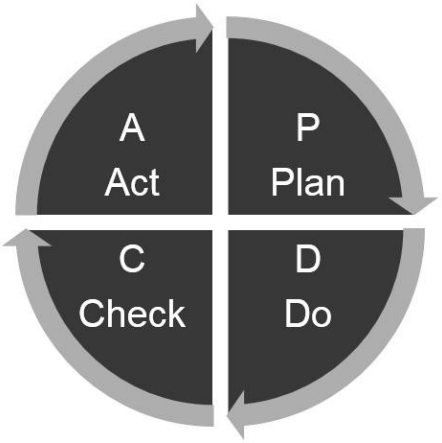


Figure 5: Deming's PDCA cycle (Ishikawa 1990:38).

The PDCA cycle should continue after the last step again from the beginning. This is the base for the continuous development (Ishikawa 1990:38).Utilising Quality control cycle: Plan, Do, Check, Act should be a part of the company's normal way of working. Goal when utilising the PDCA is to first: Stabilise the system and reduce deviation in the process. After process has been stabilised the development can begin. Utilising PDCA Small steps need to be taken to reach the goal ideal state of the department (Figure 6). (Case Company 2013.)

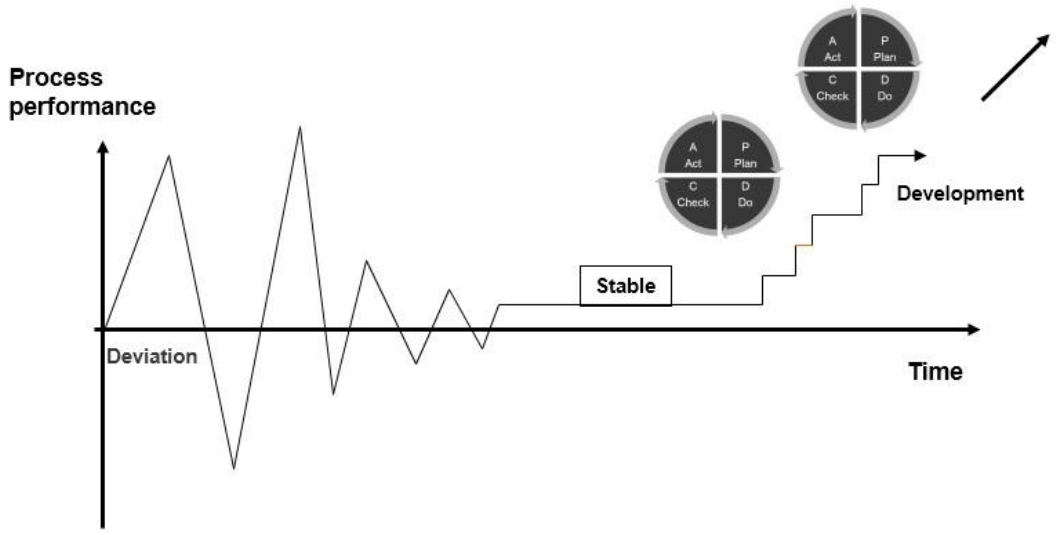


Figure 6: Utilizing quality control cycles to improve process performance (Case Company 2013).

2.6 Measuring performance

Purchasing performance should be measured due to the fact that it improves decision making by providing analysed data that divides results and variances from each other. It can improve communication between departments when measurement is providing data that explains cross-departmental tasks and issues. Measurement adds visibility to the company's actual situation when compared to set target levels. Visibility can be seen as feedback to the management and individual department workers. When done correctly this can also add motivation of the workers. Target setting should be linked to department and individual goals and development activities. (Van Weele 2015:253.)

Evaluation of performance targets should be done regularly and measurements should be established on department and individual workers level. If correct measurements are in place employees can link their individual targets and development on those personal achievements in correlation to the success of the whole department. If this kind of

correlation between individual and department targets is achieved it will automatically direct the employees to strive towards better results. (Van Weele 2015:253.)

Operational purchasing has a role in the total quality control. Delivered goods need to conform to given requirements and specifications. Measuring parameters for quality control can be production and incoming inspection rejection rates, number of quality claims to supplier and supplier non-conformity cost. (Van Weele 2005:256-259.) Setting up performance measurement can be defined by management, Opinion of experts working on the given field, benchmarking other similar companies. Every measurement should be to some extent be based on past performance. Understanding that the trend of the past can continue. (Van Weele 262-263.)

Van Weele states (2015:264) that a common method is to follow performance on a given time frame. Analysis of past data is important when defining target levels because it can be used as a base and reasoning when communicating the targets forward. Measurements should be crafted in a way that they can be linked to department working processes. Regular follow-up, reporting and adjustments on measured target levels is important. Measurement should also be kept as simple as possible. Common mistake is to have too many and too complicated measurements. (Van Weele 2015:264.)

2.7 Supplier quality assurance

Quality assurance is seen as protection against quality issues in a form of an early warning. These warnings can prevent both external and internal quality issues. Objective evidence is needed for assurance. Quality assurance for products is achieved through direct sensory examination of the inspected product. (Juran 1988:9.2.) Evidence creates the assurance that is a lot of facts. For products this is evidence is collected from inspection results (Gryna 2001:659).

Van Weele (2005:195-196) states that an approach based on prevention is taken in to use in many companies to improve supplier quality. Preventive approach for purchasing includes two points were Supplier quality assurance methods are needed: Sample inspection procedure and periodic verification. *Sample inspection* refers to an initial

sample that supplier produces that will be inspected by the customer. Internal testing at supplier will be done to check that the product complies with the given requirements. Periodic verification is a process where sampling procedures have been implemented to randomly check incoming products. In this phase cooperation with the supplier is vital for achieving continuous improvement on product quality. (Van Weele 2015:196-197.)

When purchasing organisation adopts supplier quality assurance responsibilities it should be ready to do considerable changes in its way of working. Clear tasks should be established, clear rules on supplier selection criteria and measurements for quality performance should be in place. (Van Weele 2015:201.)

2.8 Summary of reviewed theories

Concluding the reviewed theories a base of the study is in Deming's (1993:98-99) appreciation of the system that depicts the way how system and process goals are associated with each other. As a system cannot exist without a goal that it is trying to accomplish. Deming's 14 points to management indicates the importance of adopting a new philosophy. Need to abandon ineffective management philosophies, adopt new more effective ways to manage quality and furthermore we need to question old way of working and not accept any quality deviations in the process (Deming 1986:26-27). This has been the carrying idea of study that change is necessary. Not all Deming's 14 steps are utilised in this study as many of them are pointed towards a whole company not just and individual department.

Total quality aspect was used to complement the theory frame. As Feigenbaum (1991:5) states in competitive industry any company's goal is when quality is considered to provide services and products into which quality is build, designed, maintained and marketed in the most efficient way possible while meeting the customer expectations. Sumanth (1998:24-25) states that if a company is able to increase its total productivity this transcends in to improved product quality and service quality, production costs will decrease and profit and market share will be improved. For all this the importance of correct measurement importance is derived. According to Sumanth (1998:65) all

improvements in total quality perspective are driven forward by measurement system that is based on measuring total productivity. This confirmed by Van Weele (2015:253) as target setting should be linked to department and individual goals and development activities.

Deming's PDCA cycle (Ishikawa 1990:38) is utilised to monitor the effectiveness of the development projects. Idea of improving the total supplier quality by initiating several smaller development projects comes from the concept of Lean continuous improvement. Lean does not focus directly on process bottlenecks and believes that overall improvements of reducing unnecessary work improves the process performance. Womack and Jones (1996:15) state that Lean is about doing more with lesser resources. Lean manufacturing means reducing work, production and workspace, waiting times again and again to achieve a lean process where value added is maximised and waste reduced to minimum.

For incoming inspection the Lean concept of flow was important. Womack and Jones (1996:22-23) state that when the biggest waste creating steps are removed from the process the next step is to create flow to the process. Value adding steps of the process should have flow. For incoming inspection Lean concept of "Pull" was not applicable. Pull means that customer are requiring the product from you rather than you pushing them your limited inventory with predefined specifications (Womack, Jones: 1996:24-25). This due to the fact that workload can be adjusted by department management and it does not have direct effect on production output.

LEAN 5S culture was reinforced according to case company policies taking it in to full use in incoming inspection. 5S has a many similarities to Deming's PDCA cycle.

3 METHODS

The purpose of this chapter is review chosen methodology and how the related data was collected.

Scientific research is continuum of ordinary observations and reasoning, that strives to solve or at least to minimize the error possibly included (Uusitalo 1991:13). Olkkonen (1994:18) concludes that Ilkka Niiniluoto has defined that branches of science can be divided in to basic sciences, applied sciences and technology. Basic sciences are descriptive sciences. Their goal is to describe, explain and understand reality. Basic sciences answer the question: why? Applier sciences mission is to act as a bridge between basic sciences and technology. Applied sciences answer the question: what should be? Technology's goal is to create new products. Technology is based on the applied sciences results. Industrial management is highly adaptable science. Its goals are rooted in the corporate life's demands. (Olkkonen 1994:19.)

Methods used in research are linked to theoretical backgrounds, data collection and adaptation thus foremost proving and interpreting the results. Method needs to convince the readers that the presented results are new and valid. (Olkkonen 1994:21.)

Uusitalo (1991:60-61) divides research in to theoretical and empirical research. Theoretical research focuses on concepts, perspectives, or theories that are linked to research problems, and the research material consist of previous researches on the given field of science (Uusitalo 1991:61). Empirical research is targeted to observe real-life phenomenon, from which new information is being systematically collected by specified scientific method. In empirical research the subject can be phenomenon's preliminary and/or theoretical describing, it's thorough and accurate describing, forecasting its future development, or evaluation and development of an operation. (Uusitalo 1991:61.) Uusitalo's partition of research methods to empirical and theoretical research has bases in industrial management's requirements (Olkkonen: 1994:62). According to Olkkonen (1994:63) research can be divided in to qualitative and quantitative research types.

Qualitative research is often used to study human habits and behaviour. Qualitative research is often linked to case studies, as it is a method of assessing findings against a

bigger scale concepts. (Shuttleworth 2008.) According to Olkkonen (1994:43,63) the form of qualitative research is linked to hermeneutics. One pivotal point of data collection in hermeneutics is taking in to consideration understanding between researcher and the phenomenon being researched. Understanding in this case means factual concepts, reasoning behind observed phenomenon, processes in researched area that are hard to measure in any given statistical method. Observation are mainly qualitative and approach towards them is based on researcher interpretation. Research cases are often unique in nature, for example new kind of working procedures, that crucial for example managing development activities. (Olkkonen 1994: 52.)

Goal of this research was very closely linked to organisational change in case company According to Uusitalo (1991:50) available data and choosing the method to be used has tight interconnection between them. Data available limits the available methods that can be used. Main targets were to improve supplier quality assurance, improve communication towards suppliers, Implement and improve utilization of lean principles in supplier quality assurance. A common nominator for these goals was the fundamental idea of transforming supplier quality from reactive towards a proactive way of working.

In lined with the given goals following research question were set:

Research questions:

- *How can we speed up the non-conformity process?*
- *How can we identify worst performing suppliers?*
- *How can we reduce the supplier quality verification / incoming inspection lead-time?*
- *How can we reduce the amount of open supplier quality non-conformity claims?*

Based on the given goals and defined research questions a *Qualitative research method* was chosen. Qualitative research method is applicable for studying empirical phenomenon and its people aspects as in this study supplier quality assurance is approached as a whole department in a company.

In more detail an *Action analytical method case study approach* was chosen. Action analytical method strives for to understand the given research subject based on hermeneutic philosophy of science. Subjects are typically connected to company's

internal management issues, where process issues are intertwined with the people aspect and their own goals. (Olkkonen 1994:72.) Therefore research is focusing on organisational behaviour, management, problem solving, decision making, development and change management. Pivotal for action analytical method is the relation between the study subject and the researcher and how the researcher interpreters these relations. Researcher can be seen as an observer for the study subject. (Olkkonen 1994:73.) Action analytical research method focuses on the research goal. This is defined by Olkkonen (1994:75) and it is described in Figure 7.

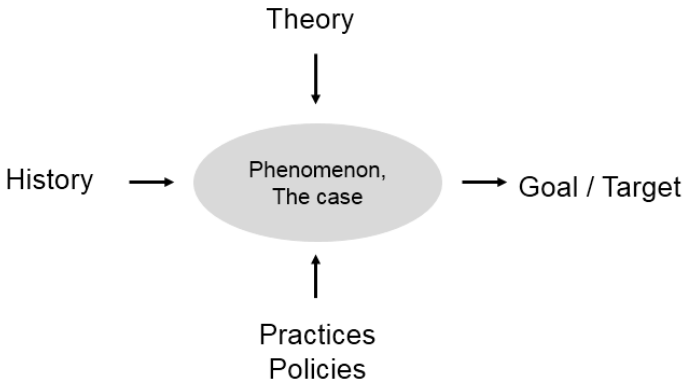


Figure 7: Action analytical research method view of related research activities (Olkkonen 1994).

Results from action analytical case study are often new hypothesis, theories, change- and development process descriptions or even normative instructions. Results can be achieved developments or goals that aim at them in the researched organisation. (Olkkonen 1994:73.)

Data was also collected from the case company's SAP enterprise resource planning system.

4 EMPIRICAL FINDINGS

The purpose of this chapter is to explain the supplier quality assurance function within the case company and to present the empirical findings of the case study. First Supplier quality assurance function is reviewed. Then strategy and development plan for the whole department. Last step is individual development projects for the department's two functions separately.

4.1 Supplier Quality Assurance in Case Company

The case company is a manufactured to order and engineered to order company. To utilize the case study data the name of the company is not revealed. The fact of large amount of new designs in production in the company increases the importance of quality assurance. Case company uses SAP enterprise resource planning system (ERP). SAP is used to monitor the supply chain of the purchased goods, quality assurance, logistics and production.

Case company's supplier quality assurance department consist of two functions:

1. Supplier Quality Engineers (SQE)
2. Supply Quality Verification (SQV)

Supplier quality engineers are responsible for nonconformity handling toward suppliers. Supplier quality engineers handle non-conformity claims coming from the production (type: QE-notification) and incoming inspection (type: QV-notification). Supplier quality engineer evaluate the content of the nonconformity claim and send it to the supplier, evaluate the corrective actions received from the supplier and monitor the supplier nonconformity handling process.

Supply quality verification stands for incoming inspection. Supply quality verification is responsible for verification of new and in production components. Supply quality verification inspects the new components, creates inspection report and makes a usage decision. For in production components sample inspection are done according to in

company standards. Inventory inspections are also done when requested. Incoming inspection is done in two different warehouses.

In the case company Production Quality Assurance (PQA) belongs under the quality department. Production quality assurance is responsible for in production inspection and reporting supplier nonconformities found to Supplier quality engineers.

4.2 Strategy plan for Supplier Quality Assurance

Case company and operational purchasing department has an existing strategy. Now that supplier quality assurance belongs to operational purchasing the issue of forming a strategy is imperative. There was no existing strategy for the supplier quality assurance function. Supplier quality assurance strategy plan need to be aligned with operative purchasing strategy. According to Pümpin (1987:x) strategy defines the future direction of the company and strategy has to identify the areas where development is necessary. To develop a competitive strategy it's actually understanding how business is going to compete, what are the goals of the business and what actions are needed to get there. (Porter 1980:xiv).

Strategy plan was divided in to 3 milestones shown in figure 8:

1. *Create supplier quality strategy plan*. Current state and immediate corrective actions.

2. *Implement supplier quality plan*. From plan to development plan and projects.

3. *Proactive supplier quality*. This is the strategic goal and the ideal state.

Figure 8: Supplier Quality Strategy Plan.

Strategy development was started with current state mapping. Goal of the current state mapping is to represent how the company is business currently doing in form of documentation. (Keyte & Locher 2004:23). To map the current state existing performance measurement were evaluated together with the managements given performance improvement targets. Data collection for current state included in depth discussion with the employees. From the given targets, current metrics, discussions and my own observations current state was established. Current state is referred in constructed strategy plan. (Figure 8) as: Create supplier Quality Strategy Plan.

At the same time future state mapping was started. Future state is the interpretation of department if no limits exists. This is the ideal state where strategy plan need to strive towards.

Strategy plan was approached by 6 common nominators for development areas based on the current state map (Figure 8).

1. Business Measurement. Evaluate and establish correct Key Process Indicators (KPI) and Process performance indicators (PPI).
2. Process development. Identify processes and related development areas. When adjustments and development projects are conducted processes need to be updated accordingly.
3. Roles and responsibilities. Remove grey areas in process responsibilities. Create clear roles and responsibilities inside the department. Also linking connections to other departments need to be established.
4. LEAN. LEAN is a chosen method in the case company for continuous improvement. Case company has certified LEAN Coaches according to SA Partners and Cardiff University standard (LSC Level 2a). Researcher will be expected facilitate LEAN trainings to support required change management activities.
5. SAP system development. Goal is to utilise SAP system as much as possible and avoid using other platforms or excel files in daily work.
6. Supplier Quality Verification development. Incoming inspection development areas. Shop floor action to improve workshop performance.

4.3 From strategy plan to development plan

Strategy list areas where development is necessary and list development suggestions in compact form. To turn strategy in to an actual development plan means that individual project need to be identified and grouped for assigned project teams to start work on. This is presented in Figure 9 for 2015. Development plan was presented to the whole department to get feedback and ensure employees commitment to the plan.

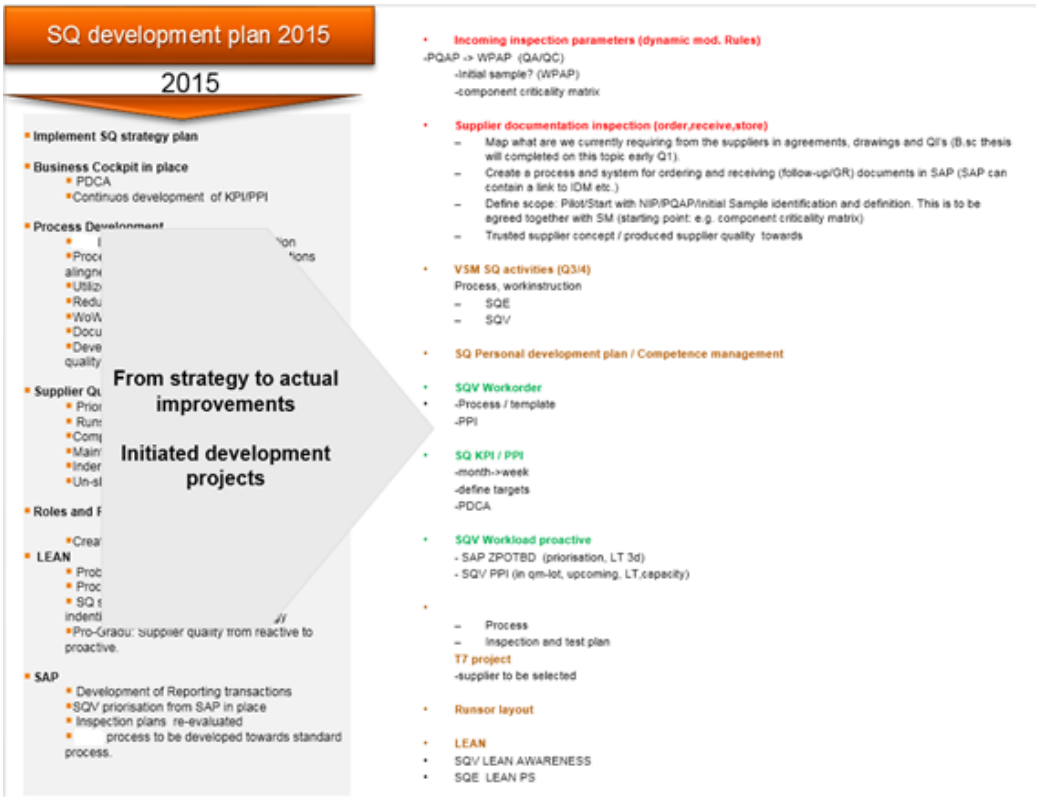


Figure 9: From strategy to development plan.

After plan was completed and communicated a schedule was done on a year level. (Figure 10) Development projects were divided on two main groups: Development projects in Supplier Quality engineering (SQE) and Supplier quality verification (SQV). Development plan was scheduled in quarter year level. This was seen as sufficient accuracy.

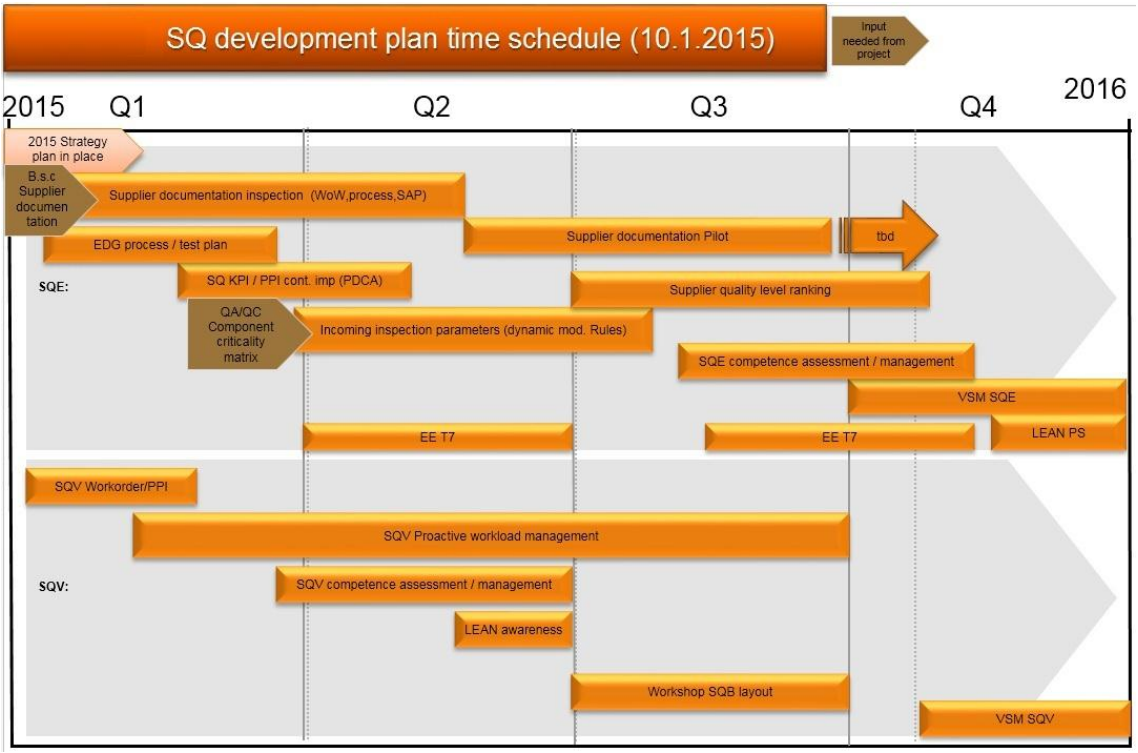


Figure 10: Supplier Quality development plan time schedule.

4.4 Supplier non-conformity

Development areas in Supplier quality engineering (SQE) are supplier non-conformity related. Supplier non-conformities found in incoming inspection and in production are reported in nonconformity claim opened in SAP. Supplier Quality Engineer is responsible for sending out the processed supplier quality claim and close it after all the process steps are completed.

4.4.1 Supplier quality engineers role and responsibilities.

Supplier non-conformity claims were distributed in the department according to personal references and capacity. This means that supplier were constantly receiving supplier claims from different quality engineers. Supply management's supplier development engineers, strategic purchasers and operational purchasers did not know who to contact in supplier claim cases. All the inquiries on non-conformity claims were directed to the department leader. There were confusion on responsibilities both externally and internally.

Supply management and operational purchasing are organised based on purchased component categories. Same category allocation was taken in to use in supplier quality engineering. Not to lose the flexibility of the previous way of working non-conformity data was collected from the SAP system for the last two years. Data was analysed and category responsibilities were given based on the non-conformity amounts and how demanding component category is rated to be. Having set component responsibilities improves communication in the supply chain both internally and externally. Working on a dedicated component area gives an opportunity to quality engineers to deepen their professional knowledge. Planning personal development plans is made easier as dedicated courses can be more easily identified and assigned. Component categories also enable personal performance measurements.

At the same time it was identified that the supplier quality assurance department did not have a development resource. A decision was made to promote one potential quality engineer as development engineer. Development resource was seen as compulsory to the

department's development although it meant that there was one less quality engineer working on supplier non-conformity handling.

4.4.2 Supplier non-conformity claim handling performance

Supplier quality engineer are responsible for handling the supplier claiming process. Two of the research question are related to non-conformity claim handling:

- *How can we reduce the amount of open supplier quality non-conformity claims?*
- *How can we speed up the non-conformity process?*

To understand why there is so many open supplier quality claims it was necessary to understand what steps are included in the non-conformity claim process. There are 9 steps in a non-conformity claim process.

1. *Inform Vendor*. After receiving the supplier claim form incoming inspection the quality engineer send the claim to supplier and operational purchaser.
2. *Perform availability check and actions*. Operational purchaser checks inventory situation and supplier capability to deliver compensatory component.
3. *Move goods to blocked stock.* Logistics moves the components from available stock to blocked stock
4. *Pack goods.* Logistics packs components ready to be delivered to the supplier.
5. *Return goods to vendor*. Logistics makes the outbound delivery of the claimed components.
6. *Assess vendor action plan.* Quality engineer is responsible to verify the corrective action sent by the supplier against the claim.
7. *Estimate cost*. Quality engineer reports the total cost collected from different departments of the non-conformity to the claim.
8. *Create notification invoice*. Operational purchasing creates an invoice or credit note of the costs and sends it to supplier.

9. *Receive credit note.* Invoicing department receives the compensation.

After all the steps are completed the supplier quality engineer can close the non-conformity claim. Non-conformity claim process includes 4-5 different departments participating in the non-conformity claim process.

To understand why the total lead time of the non-conformity process long individual task lead times were calculated. Figure 11 shows completed task lead times in days and amount of tasks closed.

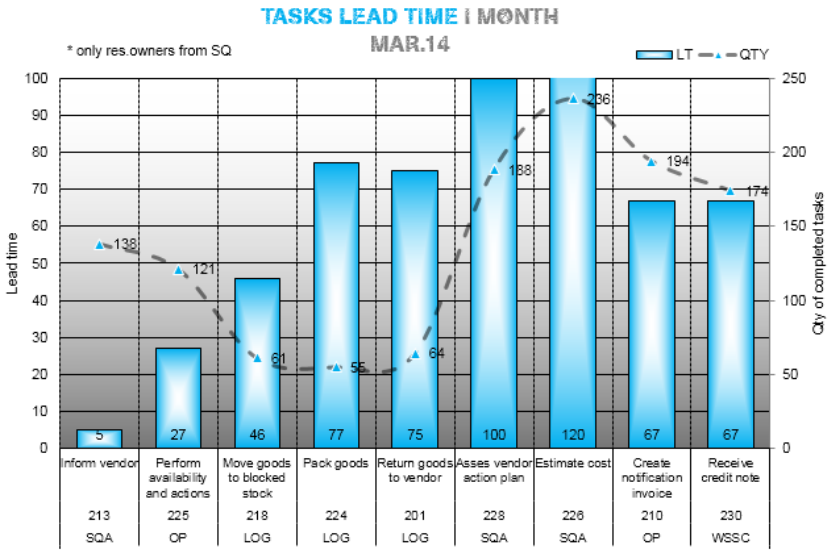


Figure 11: Non-conformity task lead times March 2014.

From the identified non-conformity task lead times a gap analyses of the process was done (Figure 13). From this analyses process bottlenecks were identified. Development projects were started accordingly. First process bottle neck was the required time to send the claim to supplier. A measurement was developed for the task lead time follow-up (Figure 12).

Notification sent to supplier process performance indicator. Definition: measuring lead time between task creation and completion (*task 213 – inform vendor*) Purpose of this indicator is how quickly notification has been sent to supplier and giving output for next task handler. Target was set at 1 day and measurement was updated weekly.

After launching the measurement lead time of the sent to supplier task quickly dropped to target level. After 3 months this measurement came obsolete as lead time was constantly at the target level. This solved the first non-conformity process bottle neck.

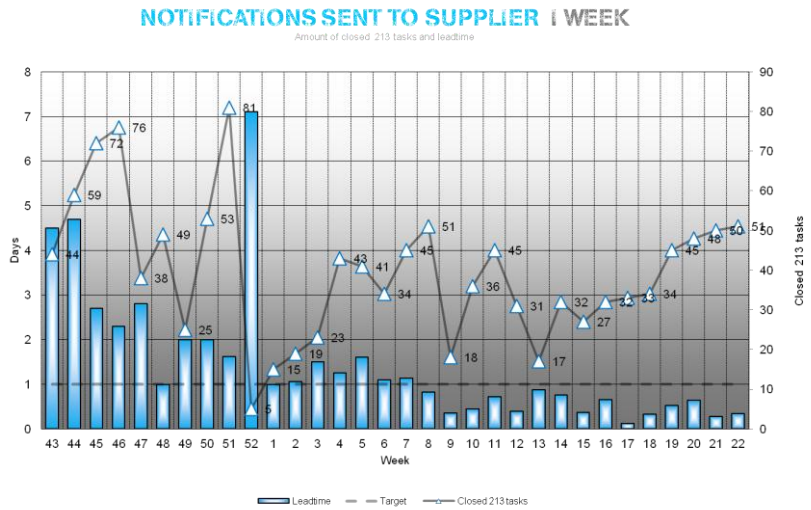
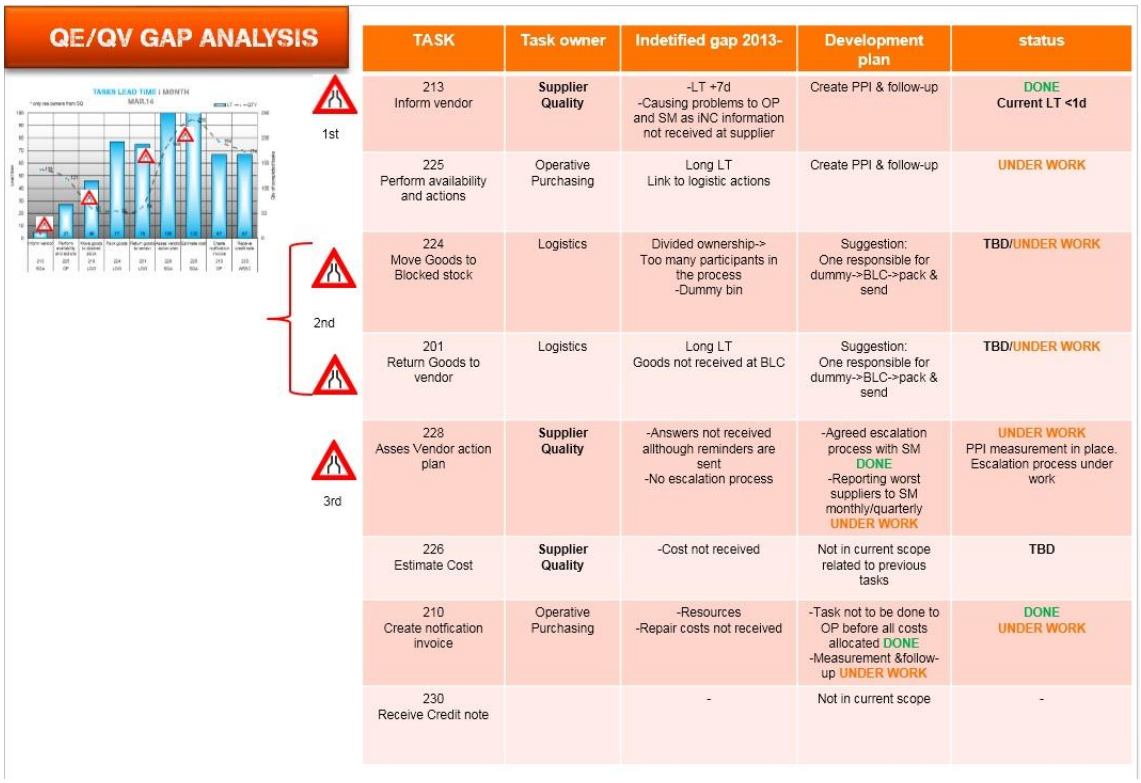


Figure 12: Notification task Sent to Supplier lead time measurement.



TASK	Task owner	Indetified gap 2013-	Development plan	status
213 Inform vendor	**Supplier Quality**	-LT +7d -Causing problems to OP and SM as iNC information not received at supplier	Create PPI & follow-up	DONE **Current LT <1d**
225 Perform availability and actions	Operative Purchasing	Long LT Link to logistic actions	Create PPI & follow-up	UNDER WORK
224 Move Goods to Blocked stock	Logistics	Divided ownership-> Too many participants in the process -Dummy bin	Suggestion: One responsible for dummy->BLC->pack & send	**TBD/UNDER WORK**
201 Return Goods to vendor	Logistics	Long LT Goods not received at BLC	Suggestion: One responsible for dummy->BLC->pack & send	**TBD/UNDER WORK**
228 Asses Vendor action plan	**Supplier Quality**	-Answers not received allthough reminders are sent -No escalation process	-Agreed escalation process with SM DONE -Reporting worst suppliers to SM monthly/quarterly UNDER WORK	UNDER WORK PPI measurement in place. Escalation process under work
226 Estimate Cost	**Supplier Quality**	-Cost not received	Not in current scope related to previous tasks	**TBD**
210 Create notfication invoice	Operative Purchasing	-Resources -Repair costs not received	-Task not to be done to OP before all costs allocated DONE -Measurement &follow-up UNDER WORK	DONE UNDER WORK
230 Receive Credit note		-	Not in current scope	-

Figure 13: Nonconformity process gap analysis.

Second bottleneck was logistics actions of moving the goods to blocked stock, packing and creating the return delivery to the supplier. Measured task lead time data is given to the logistics department to use. Logistics department was not aware of their process lead times. This led to logistics internal development project being launched were restructuring of the outbound logistics process was done to reduce the lead time.

Third non-conformity process bottle neck was receiving corrective actions from the supplier. Task Assess vendor action plan process performance indicator was created (Figure 14). Definition of the measurement is measuring lead time between task creation and completion (task 228 – assess vendor action plan). This indicates the consumed time to receive response from supplier.

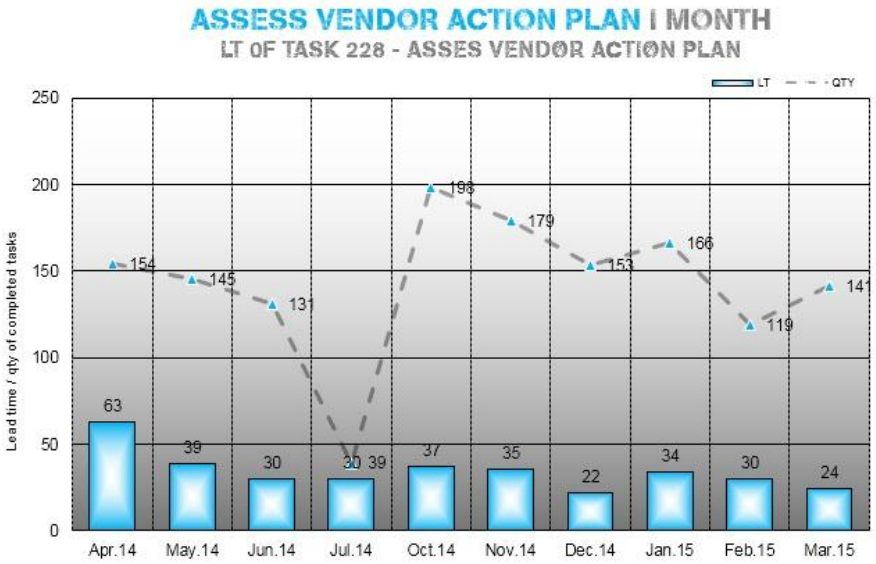


Figure 14: Task Assess vendor action plan lead time measurement.

Supplier corrective actions is quality wise one of the most important tasks. Receiving corrective action from supplier indicates that supplier has analysed the issue and taken corrective action to resolve the root cause and remove it. Issue with the receiving responses from supplier was that there was no actual way of working or process to follow-up late supplier responses. Following steps were taken in to align the way of working:

1. Decide clear time limits for receiving the corrective actions.
2. Create a process of sending an reminder
3. Create an escalation model if reminder fails to provide the corrective actions.
4. All steps should be easily measurable

Discussions were held together with the quality engineers, operational purchasing and supply management to agree on process steps and time constrains. It was agreed that supplier has 3 weeks upon on receiving the non-conformity claim to give response. If no response is received within 3 week a reminder is sent. After 1 week of sending the reminder the non-conformity claim is escalated to Supply management, Supplier development engineer. Supply management has better possibilities to influence the supplier base. Reminder and escalation is done by in SAP using notification tasks. This enables the lead time and amount measurement. Process is represented in figure 15.

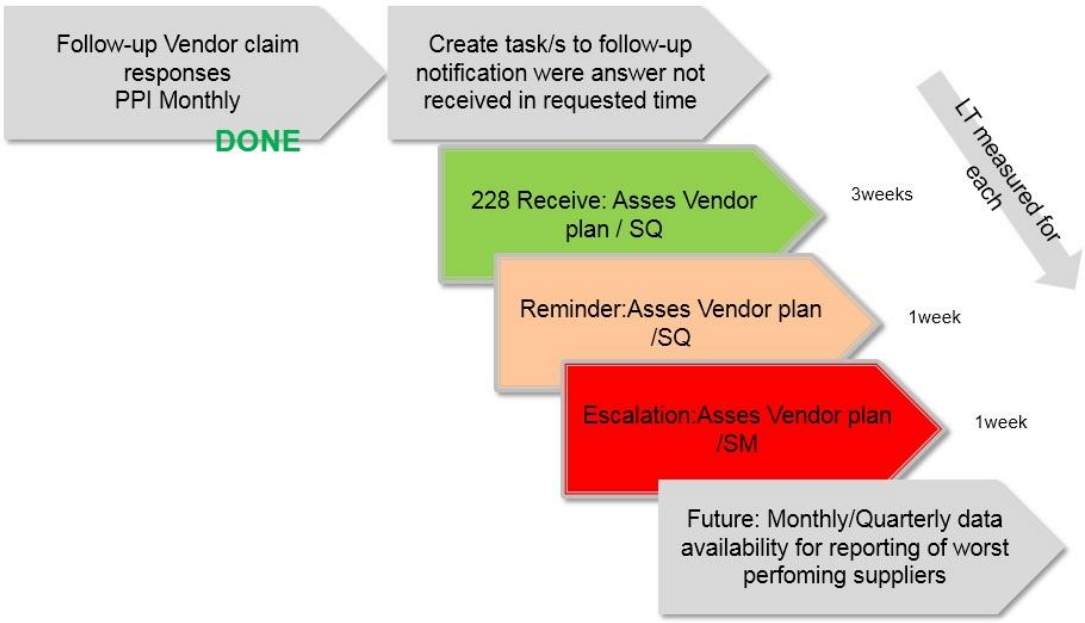


Figure 15: Vendor claim response monitoring process.

This process also enables supplier performance evaluation based on the amount of cases where reminder or escalation was needed. This data can used as one part of assessing supplier total performance. This is related to the research question:

- *How can we identify worst performing suppliers?*

Importance of task lead times were communicated to all process participant to raise awareness of the impact that long task lead times have on the non-conformity process. Figure 16 illustrates the task lead time reduction during one year time span.

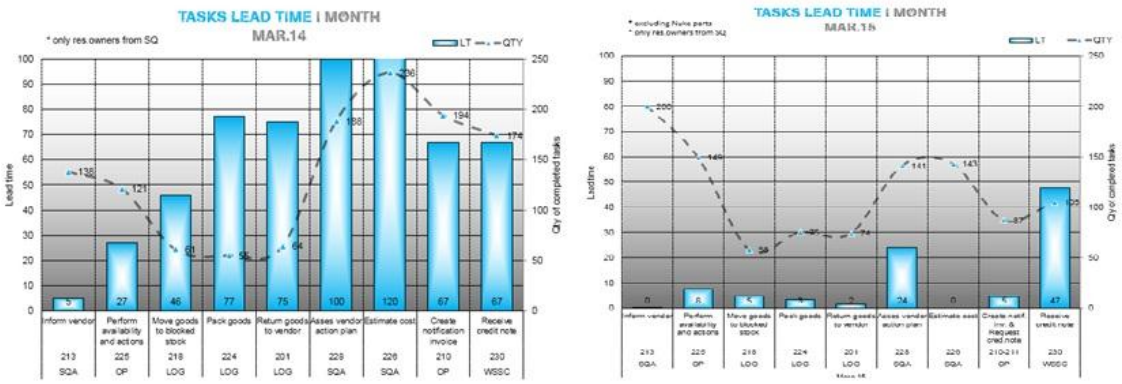


Figure 16: Non-conformity task lead time development from March 2014 to March 2015.

4.4.3 Supplier non-conformity costs

As stated in the previous paragraph amount of reminder and escalation task can be used as a part of identifying worst performing suppliers. This is linked to research question:

- *How can we identify worst performing suppliers?*

Understanding internal costs created by supplier non-conformities can be one way of approaching the concept of supplier performance. Non-conformity cost were previously required to be reported individually to SAP claim by each task owner. This was seen too laborious by the task owners and end result was that rarely any cost were recorded to the non-conformity claim. Supplier quality cost can be calculated in many ways. The approach here chosen is to focus on internal handling cost that can be mapped from the system. There is two types of non-conformity claims coming from the production (type: QE-notification) and incoming inspection (type: QV-notification). When quality issues are detected and claim created this is considered to produce costs to case company. There are two types of usage decisions that can be used in a non-conformity claim:

- *Delivery Rejected.* Whole delivery is rejected and claim is sent to supplier.
- *Accepted with remarks.* Delivery contains minor quality issues and the batch can be accepted. A claim of the deviations is sent to supplier.

Used tasks in QE and QV notifications were listed according to usage decision. Used hours for each activity were collected from the department taking part in the process. Hourly cost was also mapped based on given department costs. From this data following table was created: Figure 17.

Delivery rejected Actions required	QE hours	QV hours	Cost €
Create QV notification		1	00,00 €
Create QE notification	1		00,00 €
Provide new material	1		00,00 €
213-inform vendor	1	1	00,00 €
226-estimate cost	1	1	00,00 €
225-perform availability check and actions	1	1	00,00 €
228-asses vendor action plan	1	1	00,00 €
218-move goods to blocked stock	1	1	00,00 €
224-pack goods	1	1	00,00 €
201-return goods to vendor	1	1	00,00 €
210-create notification invoice	1	1	00,00 €
230-receive notification invoice	1	1	00,00 €

Accepted with remarks: Actions required	QE hours	QV hours	Cost €
Create QV notification		2	00,00 €
Create QE notification	2		00,00 €
213-inform vendor	1	1	00,00 €
226-estimate cost	1	1	00,00 €
228-asses vendor action plan	1	1	00,00 €

Figure 17: Non-conformity cost data depending on usage decision and notification type.

From this data it cost can be calculated and inserted in to a matrix (Figure 18).

Figure 18: Fixed non-conformity costs.

The fixed non-conformity cost is easy to utilize and the cost can be inputted by the quality engineer. Costs do not have to be collected from the process task owners. Notification task owner can still add additional cost to the claim if those are identified to exist.

To support the identification of worst performing supplier a process performance indicator (PPI) was established. Amount of non-conformity claims and cost created in euro € are measured on a monthly level. A list of top 5 worst suppliers is created based on the cost experienced by the case company (Figure 19).

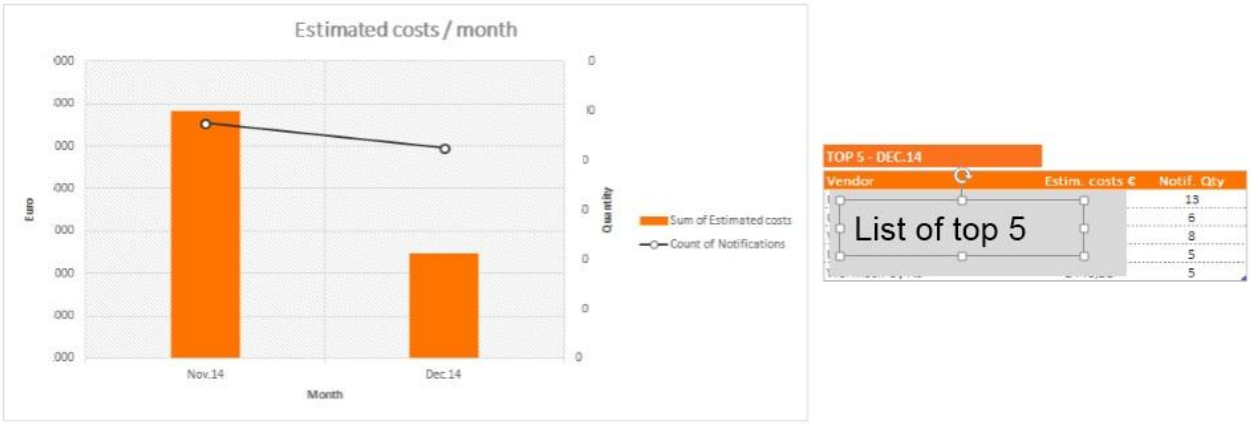


Figure 19: Non-conformity estimated costs.

4.4.4 Extended enterprise projects

Now there are two ways of identifying worst performing suppliers based on the non-conformity costs and their ability to provide corrective actions in time to the case company. Supplier quality assurance should react on these indicators and aim at improving supplier quality. A model for extended enterprise projects was identified as necessary. In the case company there has been already extended enterprise projects but in the purchasing led projects focus has been on cost reduction and delivery reliability. A project format consisting of 7 steps was created. Goal is that these projects will be led by supplier quality assurance department.

7 Steps of the extended enterprise project:

1. Analyse all the nonconformity data. Amounts, Lead times, costs and categorisation of the non-conformities.
2. Identify a supplier to proceed with based on the selected data.

Steps 1 and 2 are done before contacting the supplier and supply management. After potential supplier is selected for the project approval and participants from supply management are requested.

3. Kick-off meeting with supplier and all participants from: operational purchasing, supply management, product engineering and production quality.
4. Responsibilities are assigned.
5. Sub-projects are defined with the responsible sub-project leaders.
6. Follow-up meetings held by the extended enterprise project leader.
7. Sustain. Processes and way of working are changed and maintained according to project findings.

Goal in the extended enterprise project is to focus on:

- Design: Quality of the drawings and manufacturability.
- Quality assurance methods: Consisting of measurement techniques and quality assurance process of the supplier.

- Quality instructions: Case company's quality instructions are reviewed and compared with the suppliers internal processes.
- Create communication channels between supplier and the case company.

As of 2015 one extended enterprise project has been completed and one is on-going. Key results from the first project are summarised below:

- Measurement uncertainty improved. Difference between supplier and Case Company internal quality assurance measurements were reduced from 8,5mm to 1mm.
- New inspections method created for the supplier products.
- Inspection records improved at supplier
- Updated quality instructions
- Communication channels agreed between supplier and case company design engineers.
- Non-conformity claimed amount reduced from 4% to 1,6 % of the total monthly delivered volume.

4.5 Supplier Quality Claim handling KPI and PPI measurements

Measurements are implemented to identify if initiated actions improve the total process (Perigord 1990:120). For non-conformity claim process a Key Process indicator (KPI) and Process Performance Indicators (PPI) are required. KPI measurement needs to be aligned with the department and unit strategy. Improvement in KPI measurements are linked to the unit's total performance. Necessary amount of PPI measurements are needed to support KPI targets. KPI measurement are linked to the research questions:

- *How can we reduce the amount of open supplier quality non-conformity claims?*
- *How can we speed up the non-conformity process?*

KPI measurement for supplier quality claim handling are:

1. Open notifications & closed notification lead time
2. Opened/Closed vendor claim quantity's and ratio between QV & QE

Open notifications & closed notification lead time KPI is giving an overall situation of open and closed notifications. Ratio between under and over 8 weeks of total notification quantity pointing a speed of the claim handling procedure. 8 weeks handling time is seen as identical. As target need to reasonable and achievable target lead time is set at 90 days. This target can be advised when achieved. KPI is updated monthly (Figure 20).

Opened/Closed vendor claim quantity's and ratio between QV & QE KPI measurement is giving an overall view of claim opened and closed quantities, ratio between production opened and incoming inspection opened claims and cancelled claims. This measurement gives an indication of how the total amount of non-conformity claim developing and where quality deviations are identified. Cancelled notifications indicate that the process has failed. KPI is updated monthly (Figure 21).

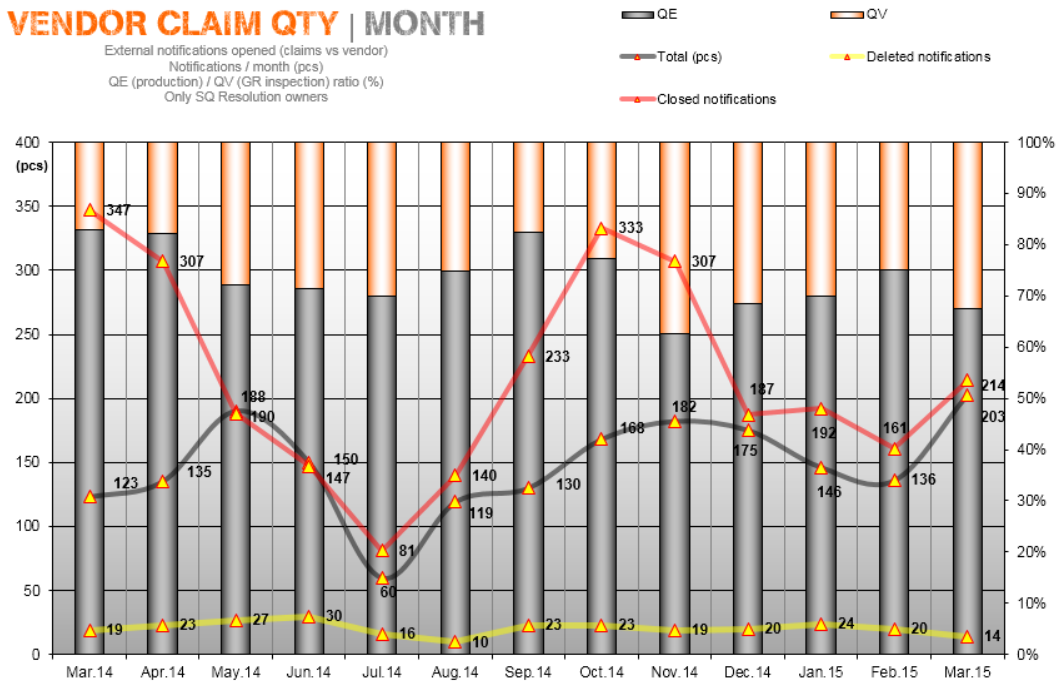


Figure 20: Open notifications & closed notification lead time KPI measurement.

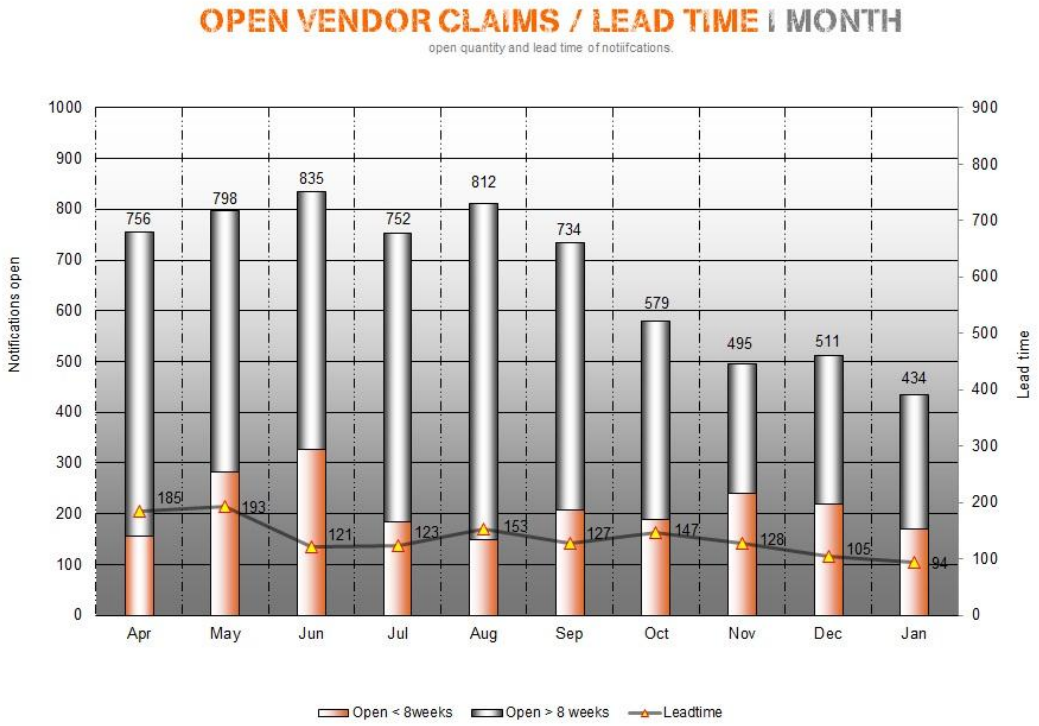


Figure 21: Opened/Closed vendor claim quantities and ratio between QV & QE KPI.

Process performance indicators (PPI's) are required to support key process indicators (KPI's). PPI should be updated on shorter intervals than KPI's. PPI's give inputs on process performance in a shorter lead time than KPI's that are reported to management monthly. Having PPI's that are updated weekly gives an early warning if process performance is not at the required level.

Process performance indicators for supplier quality:

- Non-conformity task lead times
- Notification sent to supplier lead time
- Assess vendor action plan
- Opened and completed notifications / quality engineer

Non-conformity task lead times (Figure 11) indicates the lead times of each non-conformity claim. With the lead time measurement process bottlenecks can be identified. Total lead times are updated monthly in contrast to other PPI's being updated weekly.

Reason for this is that updating the measurement is extremely laborious. This measurement is shared with all the non-conformity claim handling process participants.

Notification sent to supplier lead time (Figure 12) gives an indication how quickly the supplier and purchasing is informed about the non-conformity. This is currently updated on a quarterly level as the measurement reached its goal in few months. Lead time drop to 1 day and has stayed there.

Assess vendor action plan (Figure 11) indicates the suppliers performance on providing the case company with the corrective actions. Receiving corrective actions from supplier is very important as the quality of corrective actions can be assessed by the responsible quality engineer. Escalation process supports the goal of receiving corrective action in given time frame.

Opened and completed notifications per quality engineer (Figure 22) gives a view for ratio of opened / closed notification within month / week. If quantity of opened notifications are higher than closed, it indicates issues in task handling and will eventually increase non-conformity notification resolution owner’s workload. This measurement is updated on a monthly and weekly level for management and department management use.

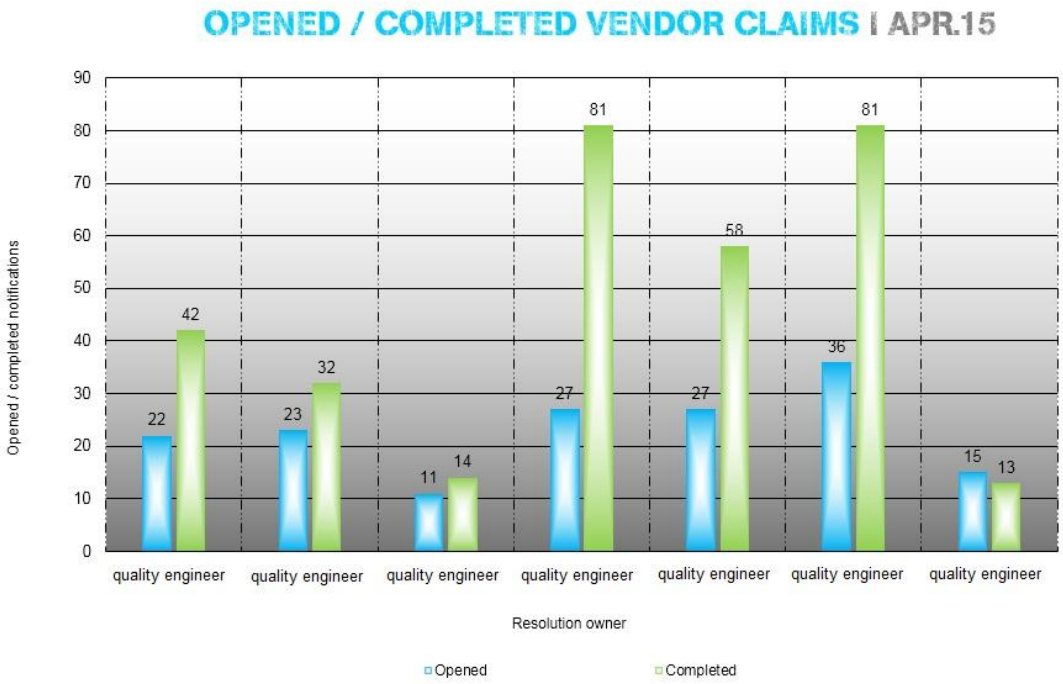


Figure 22: Opened and completed notifications / quality engineer PPI measurement.

Having key process- and process performance indicators add very little value if not communicated properly. Case company's SQA department only had separate meetings weekly for supplier quality engineers and supply quality verification. To have the whole SQA department aware of the current situation following model was developed to have a constructed way of communicating targets and status quo (Figure 23).

- Supplier Quality Verification (SQV)

Monday: Short weekly kick-off meeting was planned. This was to last only 5-10 minutes. The goal of the meeting is go through the work situation, work priorities and agree accountabilities for the coming week.

Tuesday: Already existing weekly meeting routine was continued. 1 hour is reserved for going through the weekly issues and process performance indicators. PPI's are compared against last week's performance.

Friday: SQA management meeting. Review PPI situation. Evaluate upcoming week's workload consisting of volume and cases that need priority. The output of this 30min to 1 hour meeting is communicated in the Monday's kick-off meeting.

- Supplier Quality Engineers (SQE)

For supplier quality engineers KPI and PPI situation can be communicated with the department television. Also management is closely situated in the same area as the quality engineer and communication is simpler than with supplier quality verification.

Thursday: Already existing weekly meeting routine was continued. 1 hour is reserved for going through the weekly issues and process performance indicators. PPI's are compared against last week's performance.

A monthly supplier quality assurance department meeting was scheduled for the whole department. Department KPI are reviewed against rolling 12 months development. On-going development actions are communicated to whole department personnel.

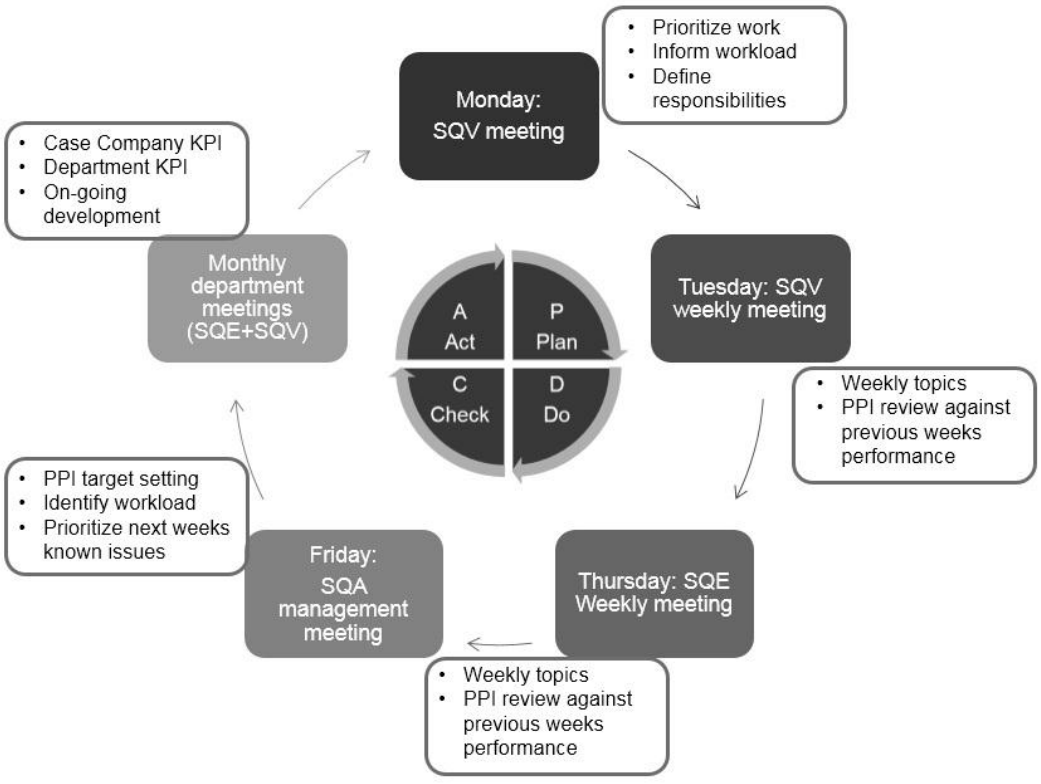


Figure 23: Utilising PDCA in KPI and PPI measurements.

4.6 Supplier quality verification development projects

Supplier quality verification or incoming inspection is responsible for inspecting new products, conduct random sampling inspection and stock inspections. Incoming inspection was identified to have too long lead time that was causing picking and production line material shortages. Lead time averaged between 8-12 days. Research question addresses this issue.

- *How can we reduce the supplier quality verification / incoming inspection lead-time?*

4.6.1 Incoming inspection layout project

Incoming inspection workshop was identified to have several issues that were not supporting the lead time improvement requirements. Ideas for improvement were collected from inspectors and by observing the working environment. Following issues were identified:

Large personal desktops that are taking a lot of workshop floor space. Tables are situated far away from where the actual inspection work is being conducted. Stone tables are used as work platform when doing the actual inspection of the component. Results are then inserted in to SAP system at the desktop. This created waste in a form of not needed movements between desktop and stone tables. Printer was also placed at the utmost corner of the workshop and retrieving printed drawings and logistic documents caused a lot of waste movements. There were not enough stone tables for all inspectors. This created mandatory waiting times when inspector was waiting for the stone table to be available. The stone tables were placed in a manner that moving a pallet in front of one would block the other table and therefore again creating waiting or unneeded movements. Long lead time and not having a dedicated place for pallet beside the stone tables congested the workshop floor.

Capacity of overhead cranes was lacking. Tables were placed so that one crane had very little use as on the other hand the other crane was occupied constantly again creating waste in form of waiting. There was no dedicated are to handle large pieces. This meant

that large components were inspected in the middle of the passageway in to the workshop blocking it totally.

A health and safety issue was created by the workshop floor being concrete. Forklifts raised dust and some inspector reported symptoms like cough and being out of breath. The concrete floor was also hard to keep clean and the dark colour absorbed the light coming from the ceiling. Good lighting is important when interpreting drawings and different measurement tool readings. These issues are visible in Figure 24.

Figure 24: Incoming inspection workshop before layout project.

Plan for corrective project steps was created and task were prioritised:

1. Workshop floor coating to remove dust issues. White colour was chosen to improve lighting conditions.
2. Additional stone table was acquired to enable all the inspectors have individual working place.
3. Large desktops were removed and replaced with 80x100cm desktop at the end of the individual stone tables. This enables all the inspection related work to be done in one place.

4. Additional crane was added to the workshop line were most of the stone table are situated to enable work to continue on each stone table without interruptions due to missing lifting capacity.
5. Dedicated areas for pallet in front of the stone tables. Stone tables are also place in a manner that all the pallet spots were accessible separately even if work was ongoing in all stone tables. This was possible due to freed space from the old large desktops even amount of the stone tables was risen.
6. Dedicated area for handling large components was dedicated in the other end of the workshop. Only one stone table is in this area adding to the available floor space. This also frees the entrance to the workshop.
7. Printer is moved in the middle of department. Less waste movement when

Layout project was conducted in the middle of the summer when volemes are low. Project lasted 2 weeks in total. The final layout is pictured in Figure 25.

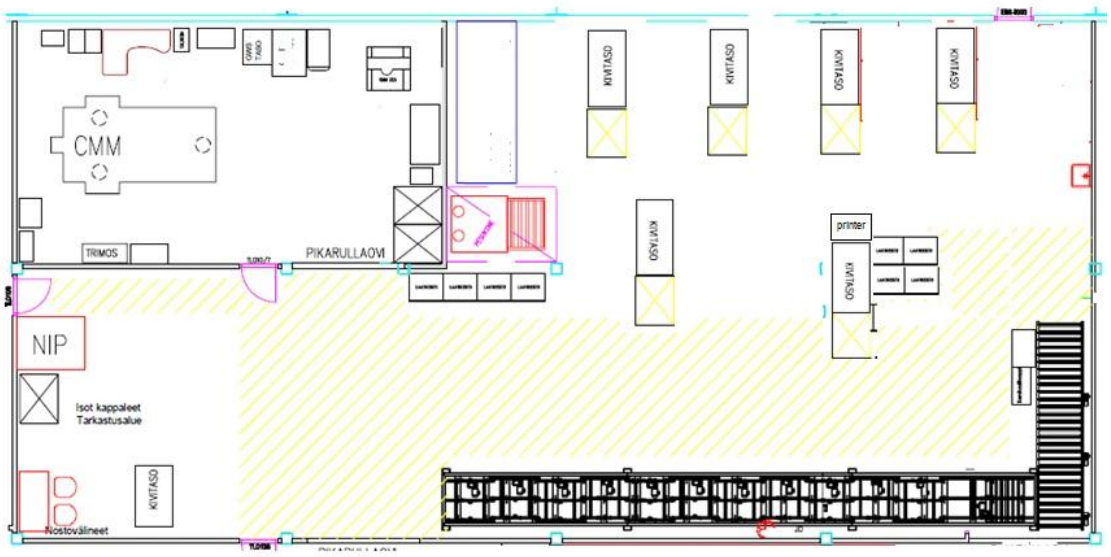


Figure 25: Incoming inspection workshop new layout.

4.6.2 5S in supplier quality assurance department

5S was originally introduced in Japan as a part of lean manufacturing. 5S is a simple 5-step process to involve everyone in the company to organize workspaces and workflow. End results include more organized and clean work area, safer and healthier working conditions, improved productivity, quality, and safety. This simple, systematic way of working was also adopted to supplier quality assurance department. 5s is already in use in some departments in the case company. A 5S auditing list was created for the workshop and office (Appendix 2). This checklist works as a visual management tool. Checklist is used weekly to inspect the marked areas cleanliness. A red indicates that audited place was not clean. If department reaches 3 weeks of without any negative audit findings a small compensation is given for the department. Also a diagram graph was developed to follow-up 5s level in the department. 5S is one of the supplier quality assurance process performance indicators (PPI). 5s also supports the new layout of the incoming inspection by maintaining its cleanliness.

4.7 Supplier Quality Verification KPI and PPI measurements

The research question for supplier quality verification is:

- *How can we reduce the supplier quality verification / incoming inspection lead-time?*

For this reason we need to establish a working lead time measurement for incoming inspection workshop. Lead time and amount of inspected lots was measured. Existing lead time measurement was modified by removing skipped inspection lots that improved statistics and adding separate lines for pilot and other special inspection lots (Figure 26). This is a key process indicator (KPI) for supplier quality assurance and it is updated monthly. Target level was set at 3 days inspection lot average lead time.

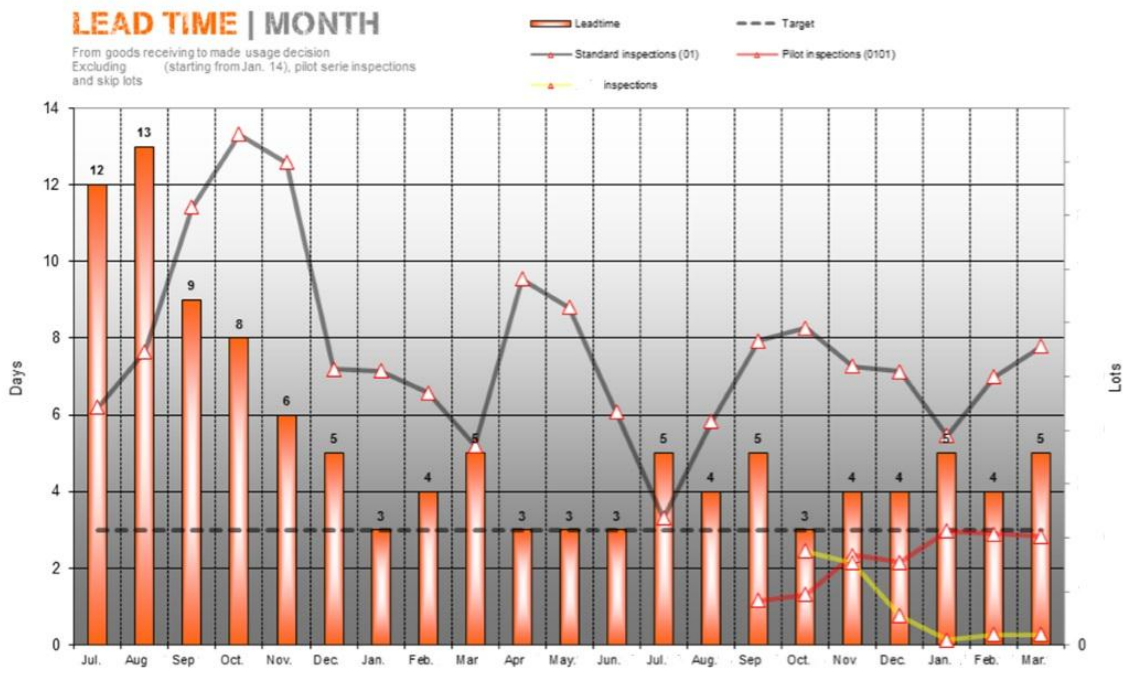


Figure 26: Supplier quality verification lead time KPI measurement.

There was no existing process performance measurement in incoming inspection workshop. There was no way to identify the performance of the individual inspectors. Inspectors did not really know are they doing a good job or not. If they would harder or take easy I did not make any difference as only on department level a measurement existed. A process performance indicator (PPI) was created to show individual results. PPI measures inspected lots per inspector (Figure: 27). Inspected lots are colour coded depending on which category they belong to. Green indicates simple products, yellow medium hard, orange hard and blue is reserved for special projects. This categorisation is used to make measurement more equal as not only the amount of inspected lots is

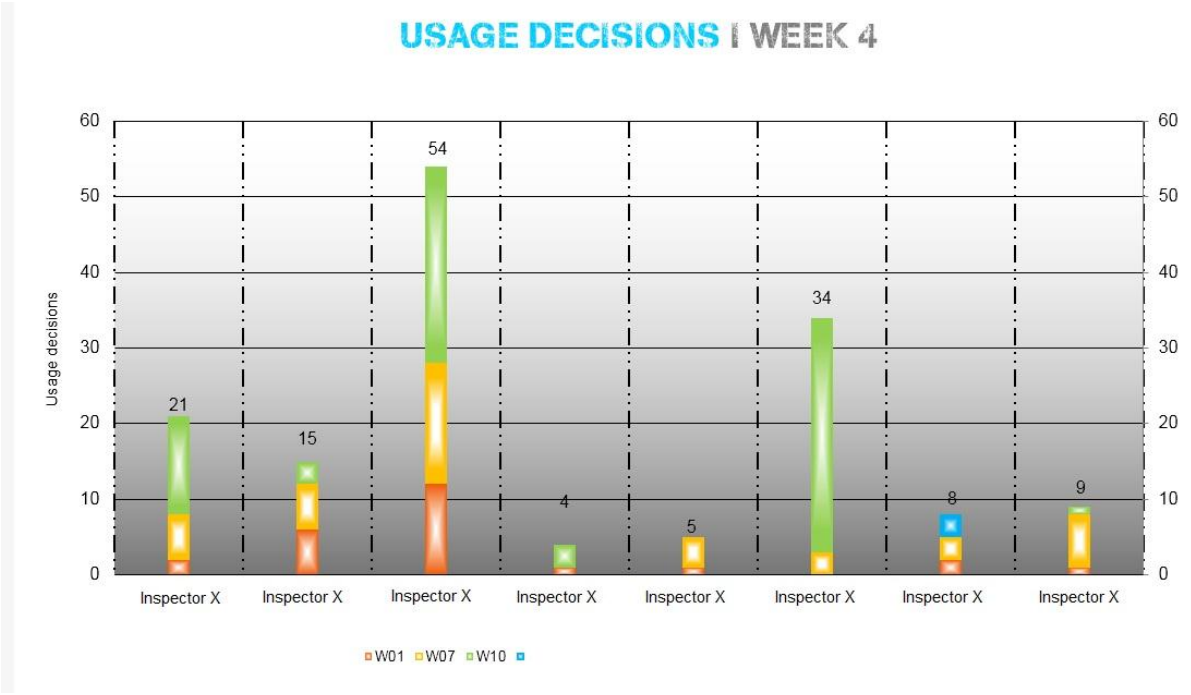


Figure 27: Supplier quality verification inspection lot PPI measurement.

5 CONCLUSIONS

The purpose of this chapter concludes the results of the study and gives ideas for further research and development.

5.1 Research questions and answers

For the study four research questions were established. Three of them were closely related to non-conformity claim handling and one was pointed out to incoming inspection. For the study target were set by the case company's management.

Research questions for supplier non-conformities:

- *How can we speed up the non-conformity process?*
- *How can we reduce the amount of open supplier quality non-conformity claims?*

  Target: *Reduce non-conformity Claim lead-time by -50%*

To achieve given targets a strategy plan was created for the whole department. This stated the vision of the department, the state were we want to get to. To achieve the given target correct KPI and PPI measurement were established. A method of actively following up KPI and PPI measurements to achieve given goals was established. Roles and responsibilities were clearly stated resulting in better ownership of the process. For escalation of challenging claims to supply management a systematic process was created.

With these developments the target of reducing non-conformity lead-time by 50% was achieved. Total reduction of non-conformity lead time was -60%. Open non-conformity claim amount was reduced by -35%

- *How can we identify worst performing suppliers?*

  Target: *Identify and categorise supplier base according to produced quality*

Measurement of supplier non-conformity costs were chosen as a criteria for measuring supplier quality. Fixed cost created inside the case company were used as base for the measurement. This data can be used together with supply managements existing quality

indicators to identify supplier quality levels. This measurement is not producing data that absolutely indicates the supplier quality level. Room for further development is seen in this case.

Research question and target for incoming inspection:

- *How can we reduce the supplier quality verification/ incoming inspection lead-time?*

  Target: *Reduce Supplier Quality Verification/Incoming inspection lead-time by -60%*

To reduce the incoming inspection lead time a complete re-organisations of the workshop floor was done to support shorter lead time. Workplaces were added to all and unneeded objects were removed. Lifting capacity was increased by adding one more overhead cranes. KPI measurement was taken in to close follow-up and PPI measurement was created. With these changes the target of reducing the lead time by 60% was met. The actual reduction varies between -50% to -75% depending on the month. Stabilising the workload is still a challenge. Not being related to study the incoming inspection workforce was reduced by 30% during the measuring period.

5.2 Managerial implications

Understanding the importance of the strategy is a key element for management in all levels of a company. Creating a clear strategy will help management to implement new methodologies and sustain the atmosphere of continuous improvement. To complement the strategy a set of correct key process indicators and process performance measurements is needed. These KPI and PPI measurement need to be constantly followed up and reported to upper management and more importantly to the department personnel. Whit out correct measurements it’s impossible to know the effectiveness of strategy. Case company’s management should give precise targets to individual departments. Management should also require that monthly progress is reported against given targets.

A department level strategy and development plan should be created. Strategy and development plan need to support the given targets. Reporting the results should also contain set of corrective actions if given targets are not met.

As competition is getting harder all the time continuous development is the key for any company to survive. To achieve this state the responsibility lays heavily on department managers shoulders. Change management is the key skill that today's managers should possess. In industries where there are long traditions on how thing are done and what is the role of the manager. In these industries traditionally manager's situational awareness is highly regarded. Manager is expected to detail on what is happening in his or hers department. For example memorizing each material shortage and be able to comment on the situation is often seen as a key requisite for a manager. When there is too much operational tasks given to the manager the strategic part of developing the function is often overlooked as secondary task.

Many good methodologies exist like the case company's chosen LEAN. LEAN is one good way to try to invest time on continuous improvement and development projects by having an existing platform and templates to work on. Main challenge for management is to get these development projects transform from projects to a normal way of working. Support for continuous improvement should come from the top management. Management should be aware of the on-going development projects and make sure that development projects have actual measurable results.

Communication is vital for a company being it communication inside the department, organisation or supply chain. As most organisations are segmented the information might not be available. This leads to disinformation and unnecessary work. Management should be able to identify the information and from that who are the intended recipients. Improving communication can resolve many issues that were not even known by the management. All levels of organisation and departments are interested on what is happening in the company, how are they performing and most importantly how the company is doing.

As non-conformity claim handling cost are defined in this study case company should review its supply agreements and check or renegotiate them if needed. Currently handling

costs are not invoiced from the suppliers. Indication to suppliers is that producing poor quality for the case company is relatively cheap. If handling cost could be invoiced from the supplier this would translate in to 1.6MEUR incoming cash flow annually. Actual total cost for non-conformities is still much higher.

5.3 Further work

During the observation period many new development areas were identified.

Supplier quality level measurement would benefit from further development. In this thesis a cost based measurement was established. This only adds one more dimension to supplier quality measurement when combined with existing measurements. To achieve a more comprehensive measurement a combined measurement and improved process reporting of costs should be created to understand the total cost of the supplier quality.

Supplier quality engineer non-conformity claim handling process includes several routine task. Manual sending of non-conformity claims and managing documentation is required to complete process. Automating routine tasks in SAP system would relieve time for more demanding tasks.

Communication inside the supply chain was improved in this project. Next step would be to involve design department in to the non-conformity management. Many non-conformities could have been prevented in the design stage if supplier’s capability to produce the specified product would have been consulted.

In the incoming inspection workshop several further development areas were identified. Currently SAP system is not prioritizing the incoming inspection workload. Products are inspected in that order they are received. This is not aligned with the production needs. Excel files are used to prioritize material shortages. Many of the material shortages could be prevented if right work order would be available. A first step towards proactive materials management was taken as a development initiative to identify incoming inspection workload was created. SAP transaction is developed to identify from incoming material flow the materials that are coming in incoming inspection.

Inspection amount are measured on an inspector level. Next step for this measurement would be to define a resource calculation tool. With this tool the amount of incoming inspection lots and available workforce could be balanced. This is possible because supplier quality assurance has the authority to decide on the inspection plans that define the amount of inspected lots.

Inspection plans define what components are coming in to the incoming inspection. Current inspection plans should be reviewed against existing quality data and component criticality. Focus should be in validating new designs rather than random sampling of the incoming material flow.

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Appendix 1: List of Total Productivity Improvement Techniques (Sumanth, 1998)

Technology-Based Techniques

1. Computer-aided design
2. Computer-aided manufacturing (CAM)
3. Integrated CAM
4. Robotics
5. Laser technology
6. Energy technology
7. Group technology
8. Computer graphics
9. Emulation
10. Maintenance management
11. Rebuilding old machinery
12. Energy conservation technology
13. Digitizing technology
14. Telecommuting
15. Bioengineering
16. Object-oriented programming
17. Fiber optics
18. Computer-aided software engineering
19. RISC technology
20. Simultaneous/concurrent engineering
21. Desktop video conferencing

Material-Based Techniques

22. Inventory control
23. Materials requirement planning (MRP)
24. Just-in-time (JIT) inventory
25. Materials management
26. Quality control
27. Material handling systems
28. Material reuse and recycling

Employee-Based Techniques

29. Financial incentives (individual)
30 Financial incentives (group)
31. Fringe benefits
32. Employee promotions
33. Job enrichment
34. Job enlargement
35. Job rotation
36. Worker participation
37. Skill enhancement
38. Management by objectives (MBO)
39. Learning curve
40. Communications
41. Working condition improvement
42. Training
43. Education
44. Role perception
45. Supervision quality
46. Recognition
47. Punishment
48. Quality circles
49. Zero defects
50. Time management
51. Flextime
52. Compressed work week
53. Harmonization
54. Work at home

Product-Based Techniques

55. Value engineering
56. Product diversification
57. Product simplification
58. Research and development
59. Product reliability improvement
60. Emulation (benchmarking)
61. Advertising and promotions

Process- or Task-Based Technologies

62. Methods engineering
63. Work measurement
64. Job design
65. Job evaluation
66. Job safety design
67. Human factors (ergonomics)
68. Production scheduling
69. Computer-aided data processing
70. Reengineering

Appendix 2: 5S inspection list and PPI measurement

SQA 5S template

0 = 1 Inspected place was not clean
1 = 1 inspected place was clean
Holiday Period

		Points/week	20	22	16	22	21	20	21	20	19	19					21	21	20	18	18	20	20	19	16	16	17					
24	Room 1		0	1	0	1	1	1	1	1	1	0					1	1	1	1	1	1	1	1	0	0	1					24
23	Office Printer area		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					23
22	Office Coffee area		1	0	1	1	1	1	1	1	1	1					1	1	1	1	0	1	1	1	1	1	1					22
21	Office cabinets		0	0	0	1	0	0	1	0	0	0					1	1	1	0	0	0	1	0	0	0	0					21
20	Office working places		0	1	0	1	1	0	0	0	0	0					0	0	0	0	0	0	0	0	0	0	0					20
19	Office floors		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					19
18	Workshop floor		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					18
17	Tools		1	1	1	1	1	1	1	1	1	0					1	1	1	1	1	1	1	1	1	1	1					17
16	Lifting tools		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					16
15	CMM		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					15
14	CMM 2		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					14
13	CMM 3		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					13
12	Stone tables		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					12
11	Area around garbage bins		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					11
10	Measurement tools		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					10
9	Pallet storing		0	1	0	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	0	1					9
8	Lifting tools 2		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	0	0					8
7	Workshop desktops		1	1	0	1	1	1	1	1	1	0					0	1	0	0	0	1	0	0	0	1	0					7
6	CMM small		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	0	0	0					6
5	CMM small 2		1	1	1	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	0	1	1					5
4	CMM small 3		1	1	1	0	0	0	1	1	0	1					1	1	1	0	1	1	1	1	1	1	1					4
3	CMM small 4		1	1	0	0	0	1	0	0	0	1					0	0	0	0	0	0	0	0	0	0	0					3
2	CC		1	1	0	1	1	0	0	0	0	1					1	0	0	0	0	0	0	0	0	0	0					2
1	CC		1	1	0	1	1	1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1					1
			41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	

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