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Balancing the quotation process by LEAN methods

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ABSTRACT

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This thesis studies the possibility to use lean tools and methods in a quotation process which is carried out in an office environment. The aim of the study was to find out and test the relevant lean tools and methods which can help to balance and standardize the quotation process, and reduce the variance in quotation lead times and in quality.

Seminal works, researches and guide books related to the topic were used as the basis for the theory development. Based on the literature review and the case company's own lean experience, the applicable lean tools and methods were selected to be tested by a sales support team. Leveling production, by product categorization and value stream mapping, was a key method to be used to balance the quotation process. 5S method was started concurrently for standardizing the work.

Results of the testing period showed that lean tools and methods are applicable in office process and selected tools and methods helped to balance and standardize the quotation process. Case company's sales support team decided to implement new lean based quotation process model.

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Tämä diplomityö tutkii mahdollisuutta käyttää lean -työkaluja ja -menetelmiä tarjousprosessissa, joka tapahtuu toimistoympäristössä. Työn tavoitteena oli löytää ja testata sopivat lean -työkalut ja -menetelmät tasapainottamaan ja yhtenäistämään tuotantoyrityksen tarjousprosessia sekä vähentämään tarjousten läpimenoaikojen ja laadun vaihtelua.

Teoriapohjana käytettiin aihepiirin perusteoksia, tutkimuksia ja oppaita. Näiden ja yrityksen oman lean-kokemuksen avulla valittiin soveltuvat työkalut ja menetelmät tarjoustiimin testattavaksi. Tuotannon tasapainottaminen, sisältäen tuoteluokittelun ja arvoketjukartoituksen, valittiin avainmenetelmäksi tasapainottamaan prosessia. 5S-menetelmä otettiin samanaikaisesti käyttöön vakioimaan työtehtäviä.

Testiajanjakson tulokset näyttivät, että lean menetelmiä voidaan soveltaa toimistoprosessiin, ja että valitut työkalut ja menetelmät auttoivat tasapainottamaan ja yhtenäistämään tarjousprosessia. Tarjoustiimi päätti ottaa uuden leaniin pohjautuvan prosessimallin käyttöön.

PREFACE

I would like to express my appreciation to those who have participated in my thesis project. Thanks to the company who gave me the opportunity to write this thesis and finish my studies. Especially thanks to my supervisor Mikko Vakkilainen, who supported and coached me during the way and showed the admirable interest and commitment about the topic of the thesis. Furthermore, thanks to my instructor, professor Janne Huiskonen for comments about the thesis and for interesting lectures in Lahti.

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Helsinki, 28.3.2015

Ville Kaukonen

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ABBREVIATIONS

BVA	Business Value Added
ERP	Enterprise Resource Planning
FIFO	First-in, First-out
IQI	Internal Quotation Inquiry
KPI	Key Process Indicators
NVA	Non-Value Added
PDCA	Plan-Do-Check-Act
PFA	Production Flow Analysis
PFD	Process Flow Diagram
R&D	Research and Development
RFQ	Request for Quotation
SMED	Single Minute Exchange of Dies
VA	Value Added
VOC	Voice of a Customer
VSM	Value Stream Mapping
WIP	Work in Process

1. INTRODUCTION

This master's thesis studies how lean tools and methods are applicable in a quotation process. A thorough literature review on the topic will be presented. A case study on a manufacturing company's quotation process is performed at the end of the thesis.

1.1 Background

Manufacturers are constantly presented with complex, multiple requests for price and delivery quotations and are challenged to respond quickly and accurately with bids that are tailored to each customer's specifications. The quotation process, from which the request for quote is received, to the bid with complete information being returned to customer, can be quite complex and time-consuming, and yet it plays an important role in the supply chains. (Buzby, et al., 2002, p. 513)

The quotation process in the case company is extensive, including several organizations and sub processes. Increasing demand for rapid and accurate quotes started to negatively affect the service level of the case company's quotation process. The current quotation process model was not flexible enough to meet the increasing demand from the markets.

1.2 Research problem

In the case company, sales offices worldwide request internal quotations from the factory's sales support team. Variable requirements in inquiries from the sales offices, and both unbalanced workloads and non-standardized work in the sales support team cause high variance in internal quotation lead times and in quality. Internal quotation lead time may vary from half an hour to several weeks, depending on the requirements of an inquiry. Controlling the variance is extremely difficult with the current quotation process model.

Another problem in the case company's quotation process is heavy positioning of new engineers in the sales support team. Due to a wide range of products, responsibilities and tasks, a lot of know-how is required. To become skilled, plenty of time-consuming training is needed. Training is given by other sales support engineers which increases workloads and withdraws resources from the quotation process itself. This reflects negatively to the customer satisfaction due to extended quotation lead times.

1.3 Target and scope of the research

In order to balance the process, lean tools and methods were considered to be studied and tested. Lean tools and methods could help to reduce the variance in quotation lead times and in quality, and to ease positioning of new engineers.

Lean tools and methods are widely used in manufacturing processes. The idea of considering lean tools and methods came up from the case company's factory floor, where lean tools and methods had been implemented. Quotation process was seen similar to a manufacturing process, although the product (quote) is intangible, and the process itself is carried out in an office environment. Thus, the objective of this study is to find out whether lean tools and methods are applicable in a quotation process which is carried out in an office environment.

Consequently, the main research question is:

Are lean tools and methods applicable in a quotation process?

Main research question is divided into two sub questions:

1. **What kind of lean tools and methods can be used in order to balance and standardize the quotation process and reduce the variance in quotation lead times and in quality?**

2. **What benefits lean tools and methods bring to stakeholders in the quotation process?**

The case study focuses on the manufacturing company's internal quotation process, starting from sales support team receiving sales office's internal quotation inquiry (IQI), and ending to sending a finished quotation back to sales office.

1.4 Research structure and methods

After introducing a quotation process and the case company, a relevant literature review will be presented in the theoretical part of the study. Several researches have been carried out on the subject of lean philosophy, lean tools and methods and of their suitability within office processes. Some recent studies focusing on lean quotation processes were found.

In the empirical part of the study, theory based lean tools and methods will be selected to be tested in the case company's quotation process. Lean methods were chosen purely out of interest to try them and because of existing experience in the factory processes. Other methods were not considered or evaluated.

Case company's lean experts helped to start the development project. Visits to the factory floor were done in order to get an overview of the lean process in practice. Lean training course arranged by the case company gave more specific information about the tools and methods possible to use in the case project.

2. PROCESS BACKGROUND

In this thesis, a case study of a quotation process in a manufacturing company will be presented.

2.1 Case company

The case company provides flow control and process automation solutions for customers in processing industries worldwide. The company has factories and supply centers in seven and sales offices in 39 countries worldwide. The product portfolio of the case company consists of valves (the main product), actuators, positioners and instrumentation components. These installed together form a valve assembly (figure 1), which can be used for example to control a flow in a process.

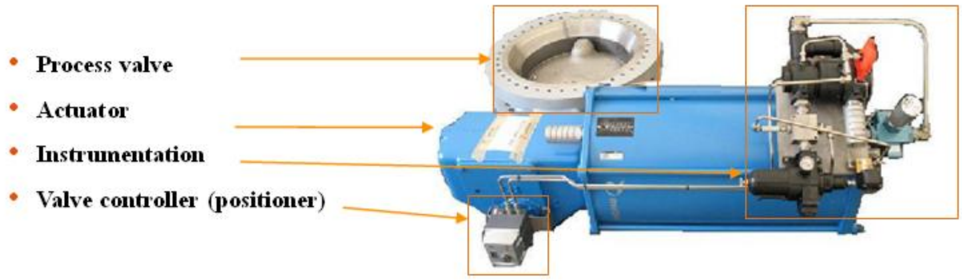


Figure 1. Valve assembly

2.2 Quotation process definition

To get the order it is first necessary to negotiate quantity, date of delivery and price with the [customer] (García-Crespo, et al., 2011, p. 824). The quotation process begins when a request for quotation (RFQ) is received from the customer and ends when the complete quote with all necessary information is submitted to the customer. The RFQ is a formal request for the suppliers to prepare [quotes] based on the terms and conditions set by the buyer (Bozarth & Handfield, 2013, p. 226). A “quote” is a document that describes the commitment by a business to the customer in terms of product specification, price and delivery (Bramham, et al., 2005, p. 413). In figure 2, a simplified quotation process resulting in submission of order is illustrated.

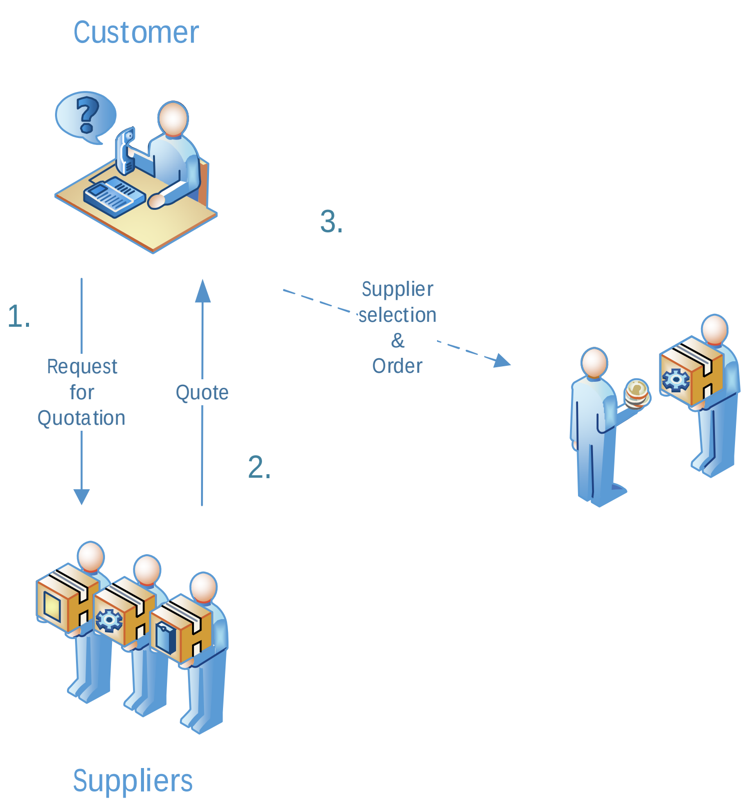


Figure 2. Quotation process in general

2.3 Quotation process in the case company

The quotation process in the case company starts when the customer submits the RFQ (appendix 1.) to the sales office. Sales office then reviews the customer requirements and prepares a quote accordingly. In case the sales unit needs technical or commercial assistance from the factory, an internal quotation inquiry (IQI) (appendix 2.) is sent to the factory's sales support team via a sales database. Sales support team then uses internal databases and ERP (Enterprise Resource Planning) system as a help to finalize quotation. In case sales support team needs further assistance with the IQI, they make a request for help to their support functions via internal query in the sales database. These support functions consist of company's other organization units such as product line, engineering, R&D (research and development), purchasing, pricing and production planning. When all necessary information is gathered by a sales support team, internal quotation can be prepared and sent back to sales office.

The quotation process flow chart in the case company starting from the reception of the RFQ and ending to the submission of the finished quote is presented in figure 3.

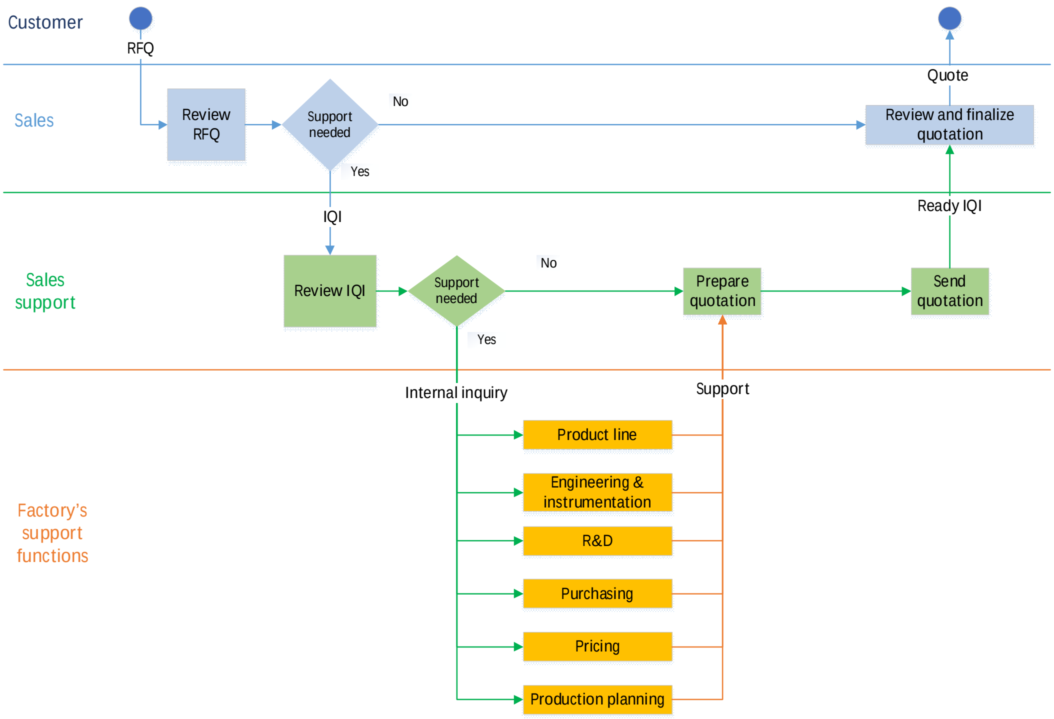


Figure 3. Case company's quotation process from RFQ to finished quote

The role of the sales support team

In this thesis a special focus is given to the role of the sales support team in the quotation process. The sales support team in the case company is the main contact body to answer the questions coming from the sales offices concerning the quotation. Sales support team provides sales offices support in terms of technical, sales system, pricing, delivery and availability issues with help of factory's internal support functions.

Sales support team consists of 10 quotation engineers, each responsible for two to three sales offices' sales support. Sales support team receives annually approximately 12 500 internal quotation inquiries from 17 sales offices around the world. Altogether, one quotation engineer manages approximately 100 inquiries per month or five inquiries per day.

3. LEAN THINKING

The term “lean” has been in use for decades in a business world. There are numerous ways to understand and interpret the term. When the statement “being lean” within an organizational context is made, the initial thought is often associated to “doing more with less” (Stone, 2012, p. 113). Liker and Morgan (2006, p. 19) describe lean as a system where parts interact, overlap, are interdependent, and work together as a coherent whole. This chapter describes the meaning of the term and summarizes the history behind it.

3.1 “Lean”-philosophy

The term ”lean production” was introduced by James Womack and Daniel Jones in their book “The Machine that Changed the World” (1990). The book was a result of a global benchmarking study which found that between Western and Japanese car firms there was a two to one gap in a productivity, quality and time in both product development and car assembly. The benchmarking data showed a better way to organize and manage customer relations, the supply chain, product development and production operations. This approach, called *lean production*, has been pioneered by one of the most successful companies, Japanese car manufacturer Toyota since the late 1940s. (Kippenberger, 1997, p. 11) According to Liker (2004, p. xii) lean production could be seen as an alternative way to mass production.

Womack and Jones describe lean thinking as “the antidote” of *muda*. *Muda* is the Japanese word for waste and specifically “any human activity that absorbs resources but creates no value”. (Kippenberger, 1997, p. 11). Rother and Shook (1999) describe lean thinking as continuous identification and elimination of waste from an organization’s processes, leaving only value added activities in the value stream (Stone, 2012, p. 114). Types of wastes will be specified later in this study.

In their second book “Lean Thinking” (1996), Womack and Jones inspired many organizations to expand lean interventions from shop floor activities to the boardroom and beyond, including the enterprise and the focus during the late 1990s and early 2000s was shifting from implementing lean exclusively on the manufacturing shop to other areas of the enterprise such as: product development, marketing, sales, service, accounting, and other white collar jobs. (Stone, 2012, p. 118) In this study, case company's intention is to implement lean in its quotation process.

The Toyota Way

The Toyota Way is a set of principles and behaviors that have been introduced by Toyota in its own booklet "The Toyota Way 2001" (Toyota Motor Corporation, 2012). It can be briefly summarized by the two pillars that support it: Continuous improvement" and "Respect for People" (Liker, 2004, p. xi). Toyota researcher, Dr. Jeffrey Liker, has explained the pillars and principles in his book: *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer* (Liker, 2004, p. 36). He has organized the principles in four broad categories starting with "P": Philosophy, Process, People/Partners, and Problem Solving:

Philosophy:

1. Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.

Process:

2. Create a continuous process flow to bring problems to the surface
3. Use 'pull' systems to avoid overproduction
4. Level out the workload (heijunka)
5. Build a culture of stopping to fix problems, to get quality right the first time
6. Standardized tasks and processes are foundation for continuous improvement and employee empowerment
7. Use visual control so no problems are hidden
8. Use only reliable, thoroughly tested technology that serves your people and processes

People/Partners:

9. Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others
10. Develop exceptional people and teams who follow your company's philosophy
11. Respect your extended network of partners and suppliers by challenging them and helping them improve

Problem Solving:

12. Go and see for yourself to thoroughly understand the situation (genchi genbutsu)
13. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly (nemawashi)
14. Become a learning organization through relentless reflection (hansei) and continuous improvement (kaizen).

Liker has modelled the above principles in "4 P" model (figure 4).

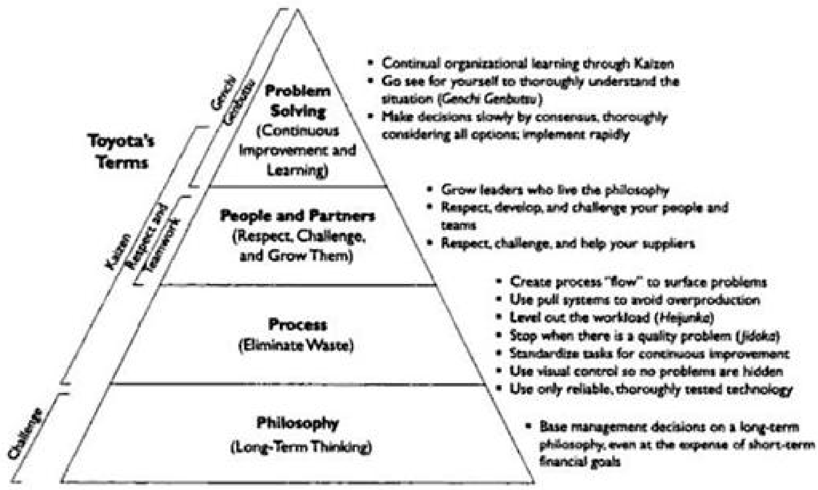


Figure 4. "4 P" model of the Toyota Way **(Liker, 2004, p. 6)**

In this study, the "4 P" model is used as a theory base and it will be referred to and explained when it is directly related to the subject researched.

3.2 Lean tools and methods

The term “lean” is so all-inclusive, that the way how it is understood in a business world varies a lot. Stone (2012, p. 113) has studied literature about lean and claims that:

Confusion surrounding exactly what lean means has resulted in numerous implementation approaches often starting and ending with misguided efforts initiated by “companies that use only the toolbox without embracing the underlying philosophy [and] are unlikely to gain more than limited and temporary results”

Liker, as well, emphasizes the same in his book (2004, p. 13) and article (Liker & Morgan, 2006, p. 5), and even indicates it referring to the “4 P” model introduced in the previous section (figure 5):

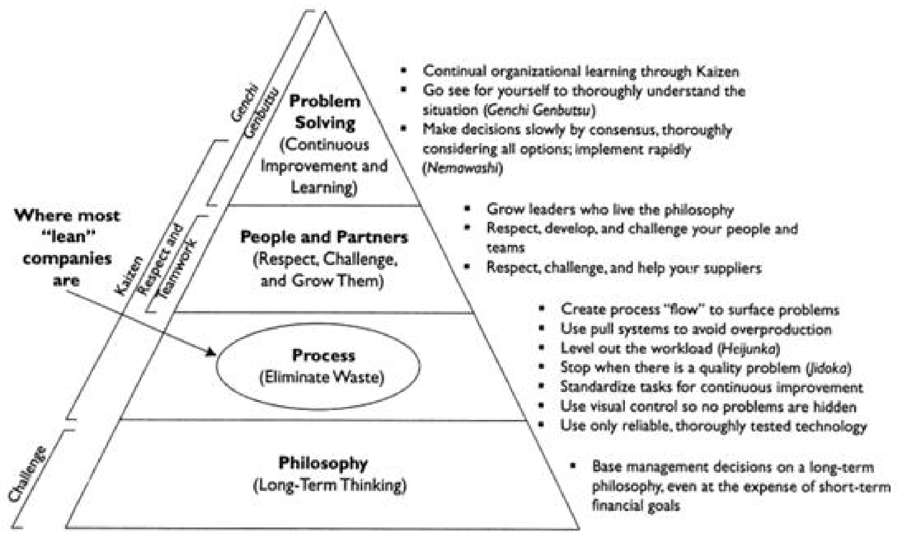


Figure 5. The “4 P” model and where the most companies are (Liker, 2004, p. 13)

The purpose of this study is to find out if lean tools and methods can be used in a quotation process. Purpose is also to take into account that lean is a comprehensive system, philosophy and culture which is difficult to adopt and implement in business environment if not understood correctly. Conclusion at the end of this study tries to find out on which level of the “4 P” model the case company is.

3.2.1 Voice of a customer (VOC)

“The next process is the customer”:

Toyota also took to heart the teachings of the American quality pioneer, W. Edwards Deming. He gave U.S. quality and productivity seminars in Japan and taught that, in a typical business system, meeting and exceeding the customers' requirements is the task of everyone within an organization. And he dramatically broadened the definition of "customer" to include both internal and external customers. Each person or step in a production line or business process was to be treated as a "customer" and to be supplied with exactly what was needed, at the exact time needed. This was the origin of Deming's principle, "the next process is the customer. (Liker, 2004, p. 23)

Internal customers, like coworkers who need assistance from another also have a voice (Martin, 2009, p. 63). In the case study sales engineers who request for quotations, are seen as internal customers to sales support team. After understanding the value from the customer’s perspective (voice of a customer), the focus shifts to the task to be accomplished and to the development of a waste free workflow, or process by which to accomplish it (Liker & Morgan, 2006, p. 16).

3.2.2 Value Stream Mapping

Whenever there is a product for a customer, there is a value stream. The challenge lies in seeing it. (Rother & Shook, 1999, p. 101)

When we think of a supply chain, we should consider it more as a value chain or a value stream. According to Chiarini (2013, p. 64), value stream is made up of all the processes and activities that the organization needs to design, develop or produce the service, deliver the product to the customer, offer assistance, and so on. Keyte and Locher (2004, p. 3) define value stream in office environment as a series of activities or processes supporting the daily production needs of the enterprise. Examples of office value streams (figure 6) range from quoting new business, to the creation of invoices, to the receipt of payment from customers (lbid., p. 3).

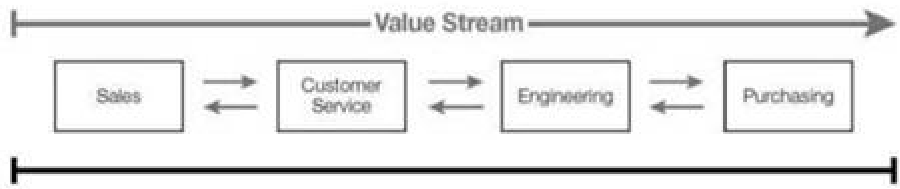


Figure 6. An example of a value stream in office environment (Keyte & Locher, 2004, p. 3)

Specifying value accurately is the first and critical step in lean thinking (Kippenberger, 1997, p. 12). Kippenberg states that problem of specifying value is that it is defined by customer but created by producer. However, instead of improving value adding activities, it is better to concentrate on the remaining ones. Effective way to reduce system complexity is to identify and eliminate products, services, process workflows, operations, and work tasks that have no value content (Martin, 2009, p. 18). Along with value added (VA) and non-value added (NVA) activities or operations, there are steps which create no value to a customer but are necessary in order to achieve the required value and sustain the business. Martin (2009, p. 7) calls them business value added (BVA) operations.

From a lean perspective, the first thing you should do in approaching any process is to map the “current state value stream,” or more simply put: the flow of information and materials through your process as it is transformed from input to final delivery (Liker, 2004, p. 29). Value stream map (VSM) is usually created by members of a value stream, starting by collecting data and metrics like key process indicators (KPI) of the current processes, and adding those on process map (figure 7).

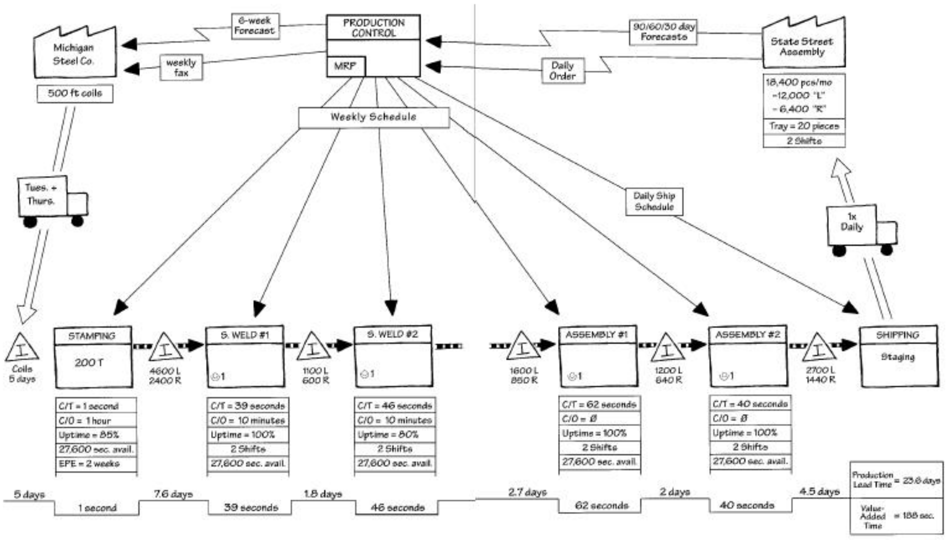


Figure 7 An example of a value stream map (Rother & Shook, 1999, p. 34)

After creating current value stream map, VA, NVA and BVA can be identified and analyzed, NVA operations can be eliminated as a waste and remaining activities can be improved by other lean methods defined later on this chapter.

After having mapped out and analyzed the current state, a future state value stream map is created with the planned improvements. Comparing a current- to future-state process map enables a project's business benefits to be estimated (Martin, 2009, p. 147).

Value stream map (VSM) helps to visualize the current state and shows where process improvements should be made. It can identify opportunities to eliminate waste, increase value added, and improve flow main stream (Chiarini, 2013, p. 32). It also helps process members to understand current versus future operational performance. Value stream mapping is a part of principle 7. of The Toyota Way: *Use visual control so no problems are hidden.*

3.2.3 Waste

Waste is what costs time and money and resources but does not add value from the customer's perspective (Liker & Morgan, 2006, p. 10). Toyota has identified seven major types of non-value-adding waste in business or manufacturing processes (Liker, 2004, pp. 28-29):

1. Overproduction - Producing items for which there are no orders, which generates such wastes as overstaffing and storage and transportation costs because of excess inventory.

2. Waiting (time on hand) - Workers merely serving to watch an automated machine or having to stand around waiting for the next processing step, tool, supply, part, etc., or just plain having no work because of stockouts, lot processing delays, equipment downtime, and capacity bottlenecks.

3. Unnecessary transport or conveyance - Carrying work in process (WIP) long distances, creating inefficient transport, or moving materials, parts, or finished goods into or out of storage or between processes.

4. Over processing or incorrect processing - Taking unneeded steps to process the parts. Inefficiently processing due to poor tool and product design, causing unnecessary motion and producing defects. Waste is generated when providing higher-quality products than is necessary.

5. Excess inventory - Excess raw material, WIP, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay. Also, extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times.

6. Waste of motion - Work is not performed using a standard method, including its procedures, materials, and tools.

7. Defects - Production of defective parts or correction. Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort.

8. Unused employee creativity (Liker has defined 8th waste himself) - Losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to your employees.

According to Liker (2004), these waste types can also be applied to product development, order taking, and the office, not just a production line. However, we will also specify office waste and its characteristics in next chapter.

3.2.4 Takt time

In the manufacturing sector, waste is often linked to takt-time (sales rhythm) (Chiarini, 2013, p. 44). Sales rhythm needs to be considered also in other sectors such as in office processes. According to Chiarini (2012, p. 33), takt time affects all the processes from sales to the suppliers because it sets the rhythm at which the product and its components should be made. A faster production could introduce inventories and a slower production could delay the delivery.

Takt time is the work time available to produce one unit from a process. It is calculated as available production time divided by required production quantity. (Martin, 2009, p. 37) As an example, if the available time per day is eight hours and eight units are required, the system takt time is calculated at one unit per hour (lbid., p. 84). Takt times can be calculated during the value stream mapping and they can be added on a map under tasks or activities of the process.

Takt time is closely related to “pull” system (Toyota Way’s 3. principle). The main target of pull systems is to produce the amount of products the customer demands at the right moment (Chiarini, 2013, p. 81).

3.2.5 5S and Standardized work

Once a process workflow has been simplified and its operations organized efficiently, its work operations must be standardized to minimize their variation. Standardization ensures work is performed the same way every time by any worker. As a result, work standardization reduces cycle time and costs and improves the overall yield of a process. (Martin, 2009, p. 30)

One of the most important lean methods used to achieve order and cleanness at work is 5S. 5S is an acronym that stands for sorting, setting in order, shining, standardizing work tasks, and sustaining the improvements (lbid., p. 80). In his book, Liker (2004, p. 150) has defined the 5S's:

1. **Sort** - Sort through items and keep only what is needed while disposing of what is not.
2. **Straighten** (orderliness) – "A place for everything and everything in its place."
3. **Shine** (cleanliness) - The cleaning process often acts as a form of inspection that exposes abnormal and pre-failure conditions that could hurt quality or cause machine failure.
4. **Standardize** (create rules) - Develop systems and procedures to maintain and monitor the first three S's.
5. **Sustain** (self-discipline) - Maintaining a stabilized workplace is an ongoing process of continuous improvement. This final step requires worker's self-discipline and management commitment. According to Smith (2013, p. 45), this is the most important step of 5S. Chiarini (2013, p. 88) claims that it is the hardest stage of all.

Like value stream mapping, 5S is an effective tool to help making problems visible. 5S is also a part of Toyota Way's principle No 7.: *Use visual control so no problems are hidden.*

3.2.6 Reduce Setup Time (SMED)

Time for setting up a job may differ a lot due to different ways or techniques of doing the same job. Martin (2009, p. 82) states:

If work tasks are done differently from one employee to another, or one job to another, then cycle time and cost will increase and quality levels decrease.

SMED is an acronym for the *single minute exchange of dies*. It is a set of tools, methods, and concepts designed to reduce the time required to set up a job (lbid., p. 90).

SMED aims at simplifying and standardizing the process by identifying the setup elements, like internal and external work tasks, and eliminating the waste of them. Internal setups are work tasks which have to be carried out in order to keep process flowing. External work tasks are activities that can take place offline, not affecting to process flow. After identification, all potential internal work tasks are converted the external work tasks in order to speed up the process. SMED has somewhat similar aspects as value stream mapping, where internal setups can be seen as value added tasks (VA) and external setups as business value adding (BVA) tasks.

3.2.7 Leveling production (Heijunka)

Leveling production (Japanese word heijunka), means smoothing out the volume and mix of items produced so there is little variation in production from day to day (Liker, 2004, p. 8). Without leveling, wastes naturally increase as people and equipment are driven to work like mad and then stop and wait, like the hare (lbid., p. 125). Also Chiarini (2013, p. 97) argues that balancing is vital; having workers waiting or rushing frantically is something that needs to be avoided at all costs.

Standardized work is far easier, cheaper, and faster to manage. It becomes increasingly easy to see the wastes of missing parts or defects. It is important to balance the flow of work through a system at operational, process workflow, office, facility, and supply chain levels (Martin, 2009, p. 85).

Leveling and balancing the workload can be accomplished e.g. by analyzing and categorizing the product range and re-designing the process flow. Job enlargement, like cross-training which involves moving workers to different machines or tasks to receive instructions from experienced workers, and job rotation which makes workers rotate and work on different machines can be used to develop workers' abilities and interest. (Chiarini, 2013, p. 98)

Leveling production belongs to the fourth principle of the Toyota Way: *Level out the workload (heijunka).*

3.2.8 Continuous improvement (Kaizen)

Kaizen has practically become a universal word (Liker & Morgan, 2006, p. 8). The Japanese term for continuous improvement is kaizen and is the process of making incremental improvements, no matter how small, and achieving the lean goal of eliminating all waste that adds cost without adding value. Kaizen teaches individuals skills for working effectively in small groups, solving problems, documenting and improving processes, collecting and analyzing data, and self-managing within a peer group. It pushes the decision making down to the workers and requires open discussion and a group consensus before implementing any decisions. Kaizen is a total philosophy that strives for perfection on a daily basis. (Liker, 2004, p. 24)

Toyota adopted kaizen philosophy from Edwards Deming (introduced in section 3.2.1) who launched the method for continuous improvement known as PDCA (Plan-Do-Check-Act) cycle (figure 8). PDCA cycle visualizes the never ending process of continuous improvement.

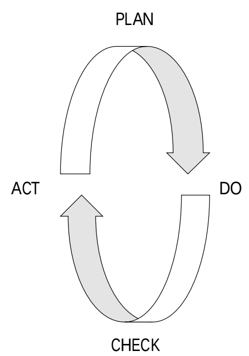


Figure 8. PDCA Cycle

Kaizen belongs naturally to the last principle of the Toyota Way: *14. Become a learning organization through relentless reflection (hansei) and continuous improvement (kaizen).*

4. FROM LEAN PRODUCTION TO LEAN OFFICE

Lean movement recently has gone beyond the shop floor to white-collar offices and is even spreading to service industries (Liker & Morgan, 2006, p. 5). Lean has, in the last few years, left the tight boundaries of production in favor of the so-called transactional processes; these are based mainly on the transaction of data and information rather than the physical elaboration of products. This way, lean office was born and applied to design, marketing, assistance, accountancy, service departments and industries as well as public administrations. Lean had to adapt and new methods were therefore born. (Chiarini, 2013, p. 11) Lean office is simply removing waste and increasing added value within the transactional processes (lbid., p. 142). This study concentrates on lean office, and the case company will use tools and methods introduced in this chapter.

4.1 Lean organization

Since lean thinking has spread from manufacturing processes to office processes, this broader model can be called as a lean organization. According to Liker and Morgan (2006, p. 5), the broader organizational culture of the firm separates the short-term improvements from the long-term lean enterprises. They warn that upstream and downstream processes must not be isolated when aimed at sustainable improvement. Womack and Jones (1994, p. 100) mention that functions should develop rules for governing how they will work together to solve problems. The goal is to serve customer, thus conflicts inside the organizations must be eliminated, or like Bodin Danielsson (2013, p. 175) argues, viewed as improvement methods.

People provide the intelligence and energy to any lean system (Liker & Morgan, 2006, p. 12). According to Smith (2013, p. 44), in order to succeed in a lean management system, organizations need to empower their people, train and motivate them and foster an environment of continuous improvement. Also autonomy, purpose and mastery should be given to employees. He claims that lean does not work well with a command and control hierarchy. Therefore dedicated and open-minded management is inevitable in lean system.

Lean organization refers to category of People/Partners (principles 9-11) of the "4P"-model introduced in chapter 3.

4.2 Knowledge work

Creating lean and responsive manufacturing operations is only part of the solution for today's organizations. Before an order reaches the shop floor, before necessary materials arrive, and before the first production step is executed, there are a host of other activities that must take place. These pre-production activities, such as taking orders, developing quotes, configuring products, and planning and scheduling production, are part of the same value delivery chain as manufacturing, and often they are the weakest link. (Hyer & Wemmerlov, 2002, p. 37)

Authors' defined "weakest link" is called as a knowledge work in the literature. Knowledge work is different from manufacturing work, usually performed in offices. According to May, (2005, p. 34) knowledge workers create information from data and reconfigure it to yield knowledge that allows businesses to advance. In knowledge work, products flown through value stream are intangible. For example orders and quotations can be defined as products in knowledge work.

4.3 Implementation of a lean system

Implementing lean in service industries has notable differences from, but some similarities to, an implementation in manufacturing (Smith, 2013, p. 43). According to Martin (2009, p. 17) organization needs to select projects based on strategic considerations. These considerations may include cost savings, cycle time reductions, quality improvements, increases in customer satisfaction, or other relevant business benefits, as well as a combination of one or more of these. Strategic considerations refer to the principle No 1. of the Toyota Way: *Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.*

Smith (2013, p. 43) suggests starting lean methods in all areas of your business when implemented, and setting target in two years or less. Yet, Liker and Morgan (2006, p. 19) claim that companies are focusing narrowly on a few lean tools in the “process” of 4P-model, discussed in chapter 3 (figure 5). They identify typical approach to be as follows:

1. **Identify a repetitive process to improve.**
2. **Apply value stream mapping to identify waste and then a future state map with waste removed (a method to map the process and show the value added and non-value added steps).**
3. **Implement the changes.**
4. **Celebrate success.**

But this is just a start. Liker and Morgan emphasize that also following thoughts need to be considered:

1. **Are the changes leading to new standardized processes that are the basis for further waste reduction?**
2. **Are people throughout the organization engaged in continuous improvement and aligned around a common set of objectives?**
3. **Are all the soft tools and harder technologies being used to support people improving the delivery of products and services to customers?**

Basically implementation process starts always from understanding the need of a customer, then creating the flow of the work by recognizing the value and removing the waste. Continuous improvement of the process keeps it lean. Ultimately, a company must envision what it wants to become. It does not need to look exactly like Toyota (lbid., p. 20).

The most important tools and methods for implementing lean in an office environment are introduced next. These tools and methods will be used in case study introduced further.

4.3.1 Kaizen event

Once the process that needs to be improved has been identified, data collecting can begin. Important factor in the success of improvements is the availability of historical data and metrics describing the process. Collecting data can be carried out for example by nominating teams which arrange so called Kaizen events. Kaizen event is a set of activities that analyze and improve a process workflow using lean and simple data analysis tools to identify and eliminate the root causes of poor process performance. (Martin, 2009, p. 24)

In their books, Martin (2009, p. 113) and Chiarini (2013, p. 63) show the activities to execute a Kaizen event. At first, goals are being discussed with the team. Team training is important if participants don’t know lean methods. Training is designed to provide a bare minimum level of competence to enable team members to understand the goals of the workshop.

Next, the event is gathered by a management or a team leader. In practice, event should be held close to working area, preferably in one room providing the necessary supplies and materials for group activities as well as catering services. A Kaizen team must be properly facilitated to ensure the full participation of all its members and it is important that everyone is encouraged to speak and contribute their ideas and give feedback every day. (Martin, 2009, p. 130)

At the beginning, the team does not necessarily have to reach targets fully; the team first and foremost has to learn how to manage workshops and how to use Lean methods (Chiarini, 2013, p. 78). After the event, the results are analyzed and presented to management and other process related members of the organization. It plays an important part because it gives importance to the event and increases awareness regarding lean methods and potential in the whole organization (lbid., p. 80).

According to Martin (2009, p. 24) Kaizen events or workshops are useful when process improvement can be executed in days. However, when major changes are required, like in the case study presented later on, integrated lean approach needs to be considered. Yet, the case study includes the testing period which can be seen as a Kaizen workshop or event.

4.3.2 Office waste

Waste in the service industry can lie hidden among files waiting to be processed, documents that require signatures, emails that have not been read, customers waiting in queues, and so on (Chiarini, 2013).

Fabrizio and Tapping (2006, pp. 5-8) have defined seven types of office wastes, which they call “Deadly Wastes”:

1. **Correction and rework**
   - time spent redoing, correcting or reworking a job
2. **Waiting**
   - people, paper, machines, information
3. **Unnecessary motion**
   - walking, reaching, bending
4. **Overprocessing**
   - work something customer doesn’t need or ask
5. **Equipment downtime**
   - waiting because of equipment (e.g. computer, printer, IT-system) downtime, ineffectiveness, or slowness
6. **Inventory and storage**
   - excess stock of tools, small equipment, books, files, inquiries
7. **Inspection**
   - not needed if work is performed correctly
   - creates more waste, like reports to be reviewed

These office wastes are closely related to Toyota Way’s wastes listed in the previous chapter but the focus is in office environment. Liker (2004, p. 29) added 8th waste (*Unused employee creativity*) which can be used in office environment as well. Keyte and Locher (2004, p. 16) call this *Underutilized people*, which means i.e. limited employee authority and responsibility for basic tasks and management command and control.

Service or office waste can be identified with the help of value stream map (VSM) and removed, or at least reduced, by implementing 5S and SMED in office.

4.3.3 Value stream map for the office

There are some distinct differences between the office and the shop floor. In the office, material flow is the actual flow of data, either on paper or electronically, that takes place to complete a service. Unlike production systems, information flows in office systems are loosely structured and use informal scheduling, which makes it difficult to identify and map their values streams. (Keyte & Locher, 2004, p. 5)

Creating VSM is the first vital step to map out the process flow. In office environment, visual control and management becomes important when discussing transactions because transactions are often hard to visualize, possibly because many are stored on a computer or cannot be identified as products (Chiarini, 2013, p. 152). Thus office waste is difficult to recognize and eliminate (Keyte & Locher, 2004, p. ix).

In their book, Keyte and Locher (2004 p. 7) list four steps to undertake value stream mapping in office:

1. **Identify product/service families (figure 9)**

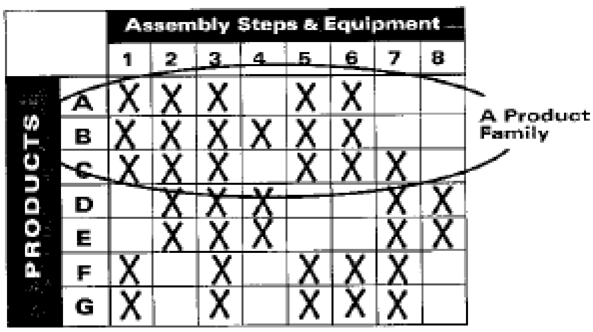


Figure 9. An example of a product/service family categorization (adapted from Rother & Shook, 1999, p. 6)

2. **Create current state VSM (figure 10)**

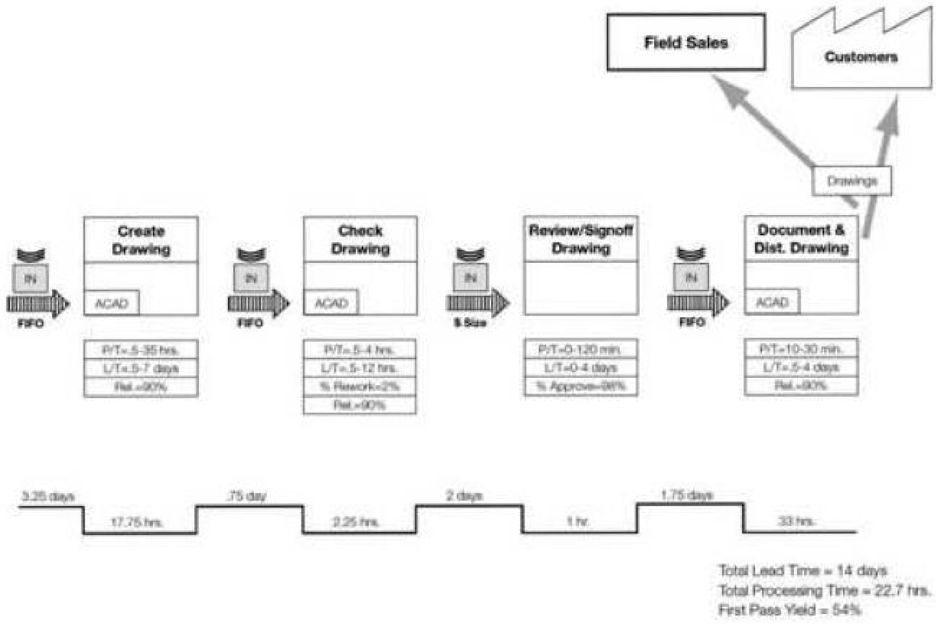


Figure 10. An example of a current state VSM (Keyte & Locher, 2004, p. 111)

3. **Create future state VSM (figures 11&12) by first highlighting the improvement needs**

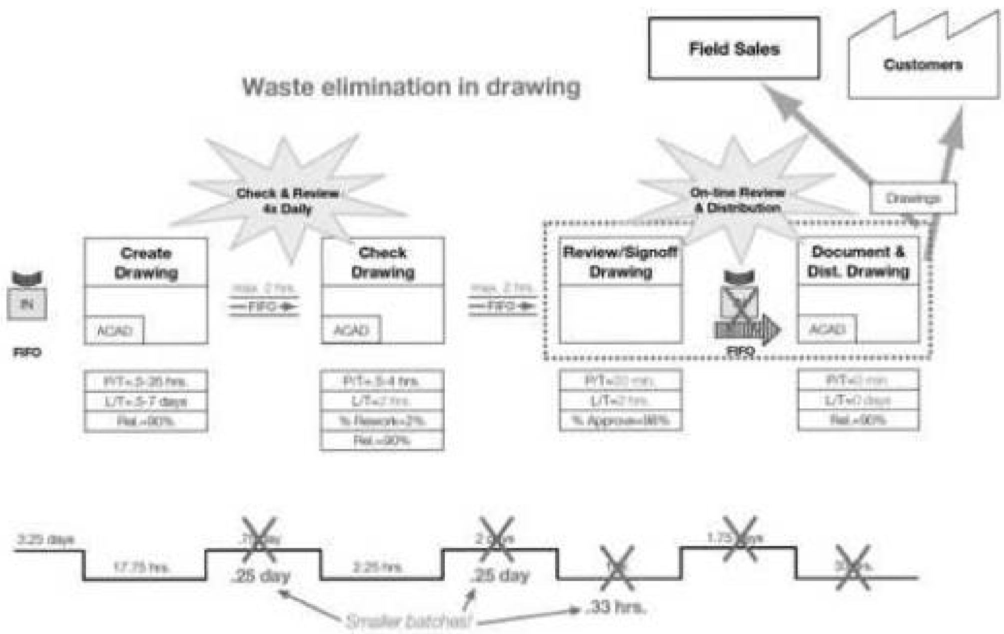


Figure 11 An example of a future state VSM with improvement needs (Keyte & Locher, 2004, p. 117)

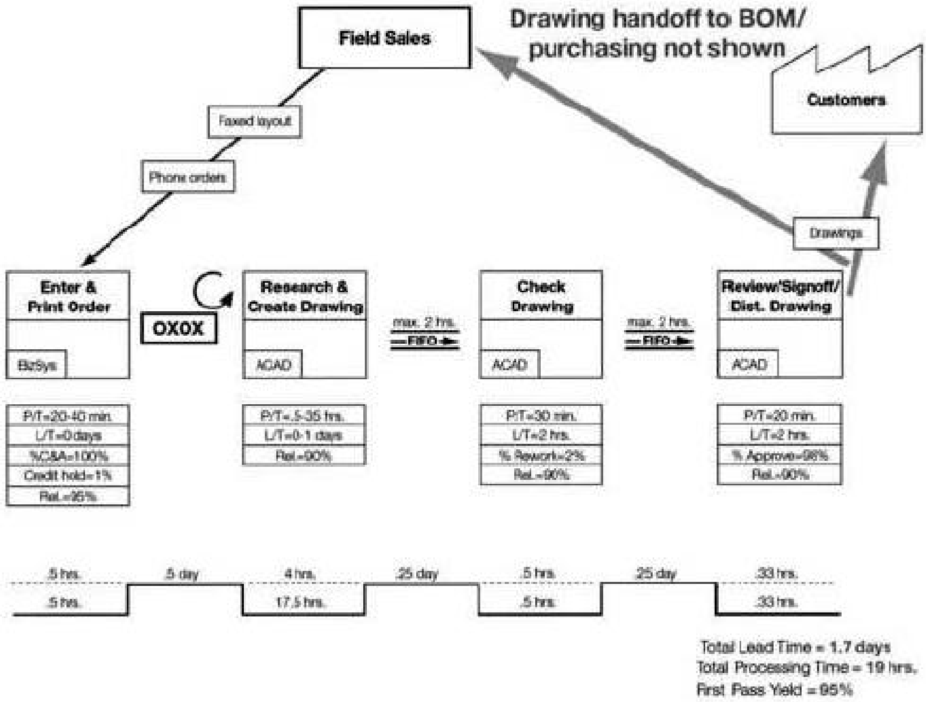
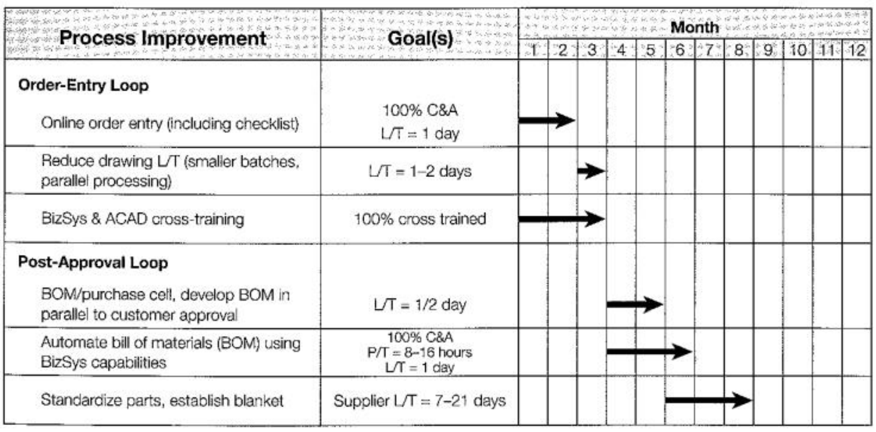


Figure 12. An example of a future state VSM (Keyte & Locher, 2004, p. 119)

4. Develop a work plan for implementation (figure 13)



Process Improvement	Goal(s)	Month 1	2	3	4	5	6	7	8	9	10	11	12
Order-Entry Loop													
Online order entry (including checklist)	100% C&A L/T = 1 day	→	→										
Reduce drawing L/T (smaller batches, parallel processing)	L/T = 1–2 days			→									
BizSys & ACAD cross-training	100% cross trained	→	→	→									
Post-Approval Loop													
BOM/purchase cell, develop BOM in parallel to customer approval	L/T = 1/2 day				→	→							
Automate bill of materials (BOM) using BizSys capabilities	100% C&A P/T = 8–16 hours L/T = 1 day				→	→	→						
Standardize parts, establish blanket	Supplier L/T = 7–21 days						→	→	→				

Figure 13. An example of a work plan (Keyte & Locher, 2004, p. 103)

The case study presented later on, uses somewhat same steps as shown above.

4.3.4 5S for the office

5 S was introduced in the previous chapter (3.2.5), and same S's (sort, straighten/set in order, shine, standardize, sustain) can be applied also into office environment (Martin, 2009, p. 81):

1. **Sort** - cleaning your desk of all nonessential items when it's easier to find materials and information
2. **Set in order** - all materials and information that remain in a work area are located in their proper location
3. **Shine** - everything within a work area be maintained clean
4. **Standardize** - work will be done the same way every time which reduces process variation
5. **Sustain** – maintain the self-discipline to sustain the improvements

Fabrizio and Tapping (2006, p. 9) have studied hundreds of companies and thousands of office processes in many types of industries and their book represents a "roadmap" helping implement 5S for the office. Roadmap contains seven phases:

1. **Prepare the Project**

   In phase one, 5S project is prepared by ensuring the management commitment, setting targets and forming implementation team.

2. **Perform an Office Scan**

   Phase two selects metrics, collects data, documents current process and visualizes it by storyboards.

3. **Sort Through and Sort Out**

   Phase three determines the criteria for sorting, place for sorted items and sorting itself.

4. **Set Things in Order and Set Limits**

   In phase four, items are moved in their own place.

5. **Shine and Inspect Through Cleaning**

   In phase five cleaning targets are determined and cleaning is carried out.

6. **Standardize Conditions & Share Information**

   Phase six determines and implements standards for three first S (sort, set in order and shine) and also creates visual controls, for example displays or signboards in order to ensure adherence to these standards.

7. **Sustain the Gains**

   Final phase seven concentrates on training and encouraging workers to sustain the new system. Involvement brings up new ideas and maintains continuous improvement.

Authors remind that every organization should create their own 5S system and the above presented "roadmap" serves only as a guide. In this study, the case company will implement 5S method in order to standardize the quotation process.

4.3.5 SMED in office

In chapter three, the tool to reduce setup or changeover time SMED (single minute of exchange dies) was introduced. Changing from one task to another is common also in an office environment. People will often stop an activity, put it aside and start another activity, then return to the first activity later on, requiring several minutes to re-acclimate themselves to the work. This can occur for many reasons, particularly when the person requires additional information or direction, or has general work interruptions. This form of mental changeover is disruptive and negatively impacts a person's productivity. Changeover time typically creates a need to batch work and extends the lead time of a value stream. (Keyte & Locher, 2004, p. 27)

4.3.6 Office cells

So called "cellular thinking", adapted from cellular manufacturing, belongs to lean office environment where fluent flow of information through a process is vital. According to Hyer and Wemmerlov (2002, p. 43), restructuring office operations to create process-complete office cells can lead to significant improvements in quality, time, cost, and other metrics important to the organization. In their article authors give examples of office cell researches.

An office cell contains resources that process, transform, transmit, and add value to a family of information deliverables. Cell's employees, act as a team, creating work protocols (standard operating procedures) to govern their activities. They focus on a family of information deliverables, thus will come to know the work quite well. They identify problems and improve the outcome of problem-solving activities. Cross-trained workers may be able to resolve issues and answer questions themselves, eliminating the need to return work to a prior step for clarification. Specialists assist in the small number of cases that require special handling. (lbid., p. 38)

Office cells also mean less time spent on setups. In information work, setup time includes both the time required for an individual to become familiar with a new piece of work (intellectual changeover) and the time needed to gather any required information or documents. (lbid., p. 39)

According to Hyer and Wemmerlov's article (p. 39, 42), companies with office cells reported reduced lead time and rework. Faster error detection and correction cycles contributed to higher quality. Due to these results, employees viewed their work as important, which resulted to increased job satisfaction and lower turnover and absenteeism.

In his book, Martin (2009, p. 79) claims that U-cells (figure 14) are more efficient than straight-line workflow designs. This is because cross-trained workers can move more easily between equipment as local demand on equipment and people changes. Also, U-shaped work cells enable employees to work more than one work station if demand on the work cell decreases. In this context, a U-shaped work cell facilitates balancing of materials and information to the work cell's takt time.

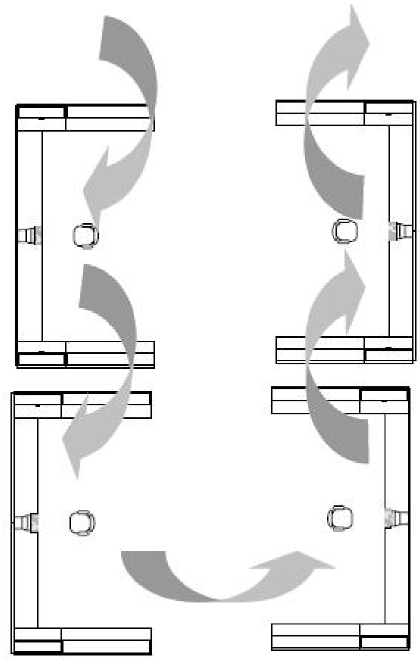


Figure 14. Information movement in U-shaped work cell office (Martin, 2009, p. 83)

4.4 Applying Lean tools in quotation process

The quotation process, from which the request for quote is received, to the bid with complete information being returned to customer, can be quite complex and time-consuming, and yet it plays an important role in the supply chains (Buzby, et al., 2002, p. 513) This study concentrates on quotation process and aims to find out whether lean methods could be applied to improve it.

Some similar researches can be found in the literature. Buzby et al. (2002 p. 513) attempted to apply lean principles to improve the quotation process of a manufacturer. They claim that quoting may incur significant amount of cost and is critical to a manufacturer's success and thereby needs to be streamlined. Streamlining comprised reduction of paperwork by using e-mails, reduction of RFQ (request for quotation) waiting time using electronic reminders, elimination of tasks using electronic solutions and reduction of cost definition time by both, coordinating with vendors and collection of historical data of costing. These methods helped to reduce the cycle time of RFQ. (lbid., p. 518)

Rayon et al. (2013) analyzed the existing quotation process of a company working in fastener industry. Company was losing bids because of tardy quotation process. Complexity of the process resulted in long RFQ lead times as well as absenteeism of personnel. This furthermore led to overloading of substitutes which resulted in quality problems. In their study, standardization by lean tools such as value stream mapping, clustering algorithms, and time studies were used to reduce the turnaround time to respond to an RFQ. (Rayon, et al., 2013, p. 250)

In the case study of Rayon et al., quotation process was first analyzed by process flow diagram (PFD) instead of a value stream map. Value added (VA) and non-value added (NVA) tasks were identified from PFD. Next, based on historical data, three part families were categorized; repeat parts, new simple parts and complex parts. After that, so called production flow analysis (PFA) standard templates were created to reduce variance of the quoting times. As a result of standardization and training, personnel also from the other functions could be used as assistants in quotation process. (lbid., p. 261)

To keep up continuous improvement, the company, which Rayon et al. were studying, revised the quotation process several months later. Then current state (figure 15) and future state value stream maps were created (figure 16) in order to identify where additional process improvements could be made.

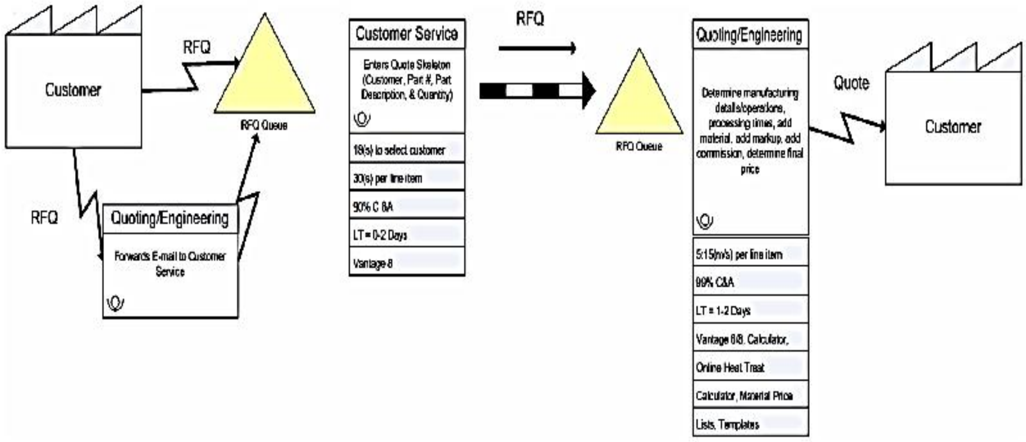


Figure 15. Current state value stream map (Rayon, et al., 2013, p. 262)

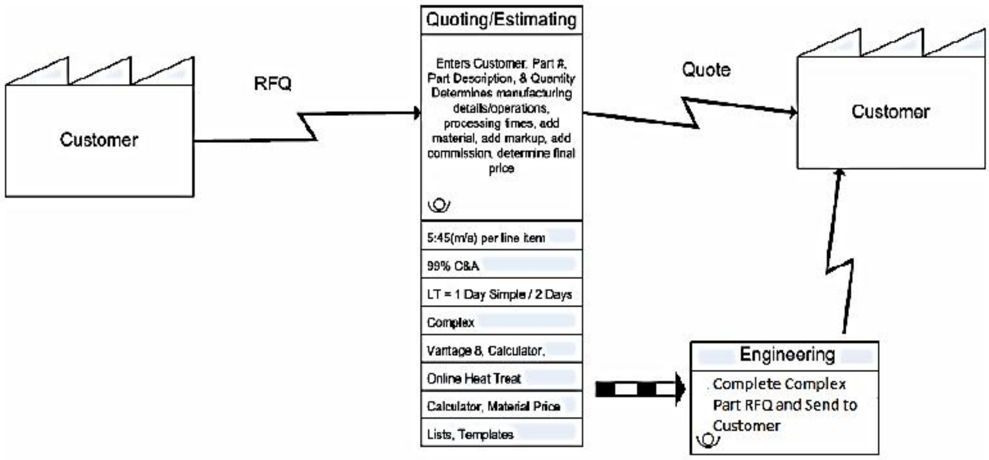


Figure 16. Future state value stream map (Rayon, et al., 2013, p. 264)

The study of Rayon et al. has somewhat similar aspects as the case study of this thesis. In the next chapter, process development by i.a. product categorization, VSM, standardization and training will be introduced.

4.5 Challenges adapting lean thinking in organization

Applying lean methods to office can be seen as a big change in work environment naturally bringing up some challenges. As discussed in chapter 3, many companies limit their exploration to a few superficial lean tools. They look for quick fixes to reduce lead time and costs and to increase quality, that almost never create a true learning culture (Liker & Morgan, 2006, p. 5). Martin (2009, p. 4) talks about organizational apathy and claims that some organizations just do not have the patience for a continuous-improvement approach, which is vital in lean thinking:

Employees will only work on tasks that they know will be measured and rewarded by management. If an organization does not require its employee to support a Lean initiative, then it will fail in practice.

Womack and Jones (1994, p. 99) also state:

When both individuals and functions feel threatened by streamlined processes, these processes won't be streamlined for very long.

It is normal that people stick to their habits and ways of working and resistance against changes arise. Liker and Morgan (2006, p. 19) claim that especially professional employees, who are typically educated, well paid, and expect to have autonomy and be creative in their work, feel threatened when the concept of lean is discussed.

According to Womack and Jones (1994, p. 94), individuals, functions, and companies have legitimate needs that conflict with those of the value stream. That’s where managers’ role and support are emphasized. It is managers’ responsibility to understand these needs and how to satisfy them. According to Smith (2013, p. 44), improvements must be seen by employees as opportunities to do higher level, more value-added work toward delivering perfection to the customer.

Cultural differences

According to Stone (2012, p. 120) the term “lean” and its association with “Japanese management” techniques, has caused confusion and difficulty when addressing the topic outside of the manufacturing context. There are also cultural differences which create challenges when applying lean into Western organizations. Liker and Morgan (2006, p. 20) have studied Toyota in Japan:

…managers and engineers work very hard. There are pressures to perform. Failure is never an option and creating constant wins means working long and late hours and stressing people. Many overseas managers and engineers working for Toyota have admitted that the pressures of being so perfect and working whenever it is needed are too much for them to sustain over an entire career.

Womack and Jones (1994) compare work tradition of Germany, USA and Japan. In Germany, focus on deep technical knowledge has led to great technical depth and an ability to compete globally by offering customized products with superior performance. However, communication between functions has been a problem. (lbid., p. 97) In United States, the individual has always been at the center creating innovativeness but causing same lack of cooperation as in Germany. In Japan, companies have focused on the needs of the entire value stream yet again weakening the innovativeness of technical functions (lbid., p. 98). Authors try to find a solution how to balance these differences.

The case study is commuted in Finland which has somewhat similar working culture as in Germany. The case study will show that the communication between the functions is slow in the case company.

5. THE CASE STUDY

The case study was conducted by a manufacturing company's sales support team. The company had implemented lean methods in manufacturing processes with promising results. Lean tools and methods were now considered for quotation process in order to balance and standardize the work and ease positioning of new engineers. Lean tools and methods could help to reduce the variance in quotation lead times and in quality.

A case study was decided to be carried out in order to see if lean tools could bring benefits to an office process. The aim was not to use all the lean tools and methods but to find the most suitable ones, and test them in real work environment. This chapter presents how the testing of the new process model was arranged, which lean tools and methods were selected and how they were used.

5.1 Preparation of the case study

Once recognized the need of a development in the quotation process, the project started with a kick off meeting where factory lean experts were providing basic information about the lean philosophy and techniques to the sales support manager and the sales support engineer, who wrote this thesis and worked as an assistant in the project (to be referred as an assistant engineer in this study). Lean experts emphasized the meaning of a project plan. A rough plan of so called road map was drawn on a white board (figure 17).

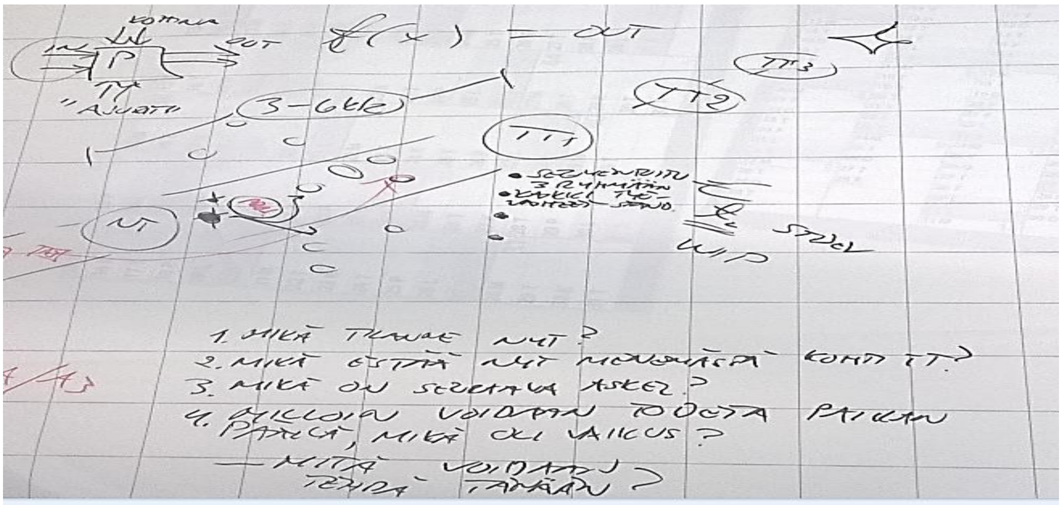


Figure 17. A rough plan of a “road map”

Road map roughly illustrates the way to achieve the target of the project. Basic theoretical questions which needed to be considered first were:

1. **What is the current situation?**
2. **What prevents us to go towards the goal?**
3. **What is the next step?**
4. **When we can see the effects of the development?**

After the meeting, it was decided to contemplate these questions and road map for a while and in the meantime search correlated lean literature; guide books, articles etc.

Before the project started, a special 2 days lean learning course was taken part by the sales support manager and assistant engineer. Learning course presented the tools and methods which were planned to be used in the new quotation process. Also example cases from the factory floor were studied in order to see lean processes in practice.

After the training, the work plan of the project was created. The plan was to implement new lean based quotation process in about half a year (figure 18).

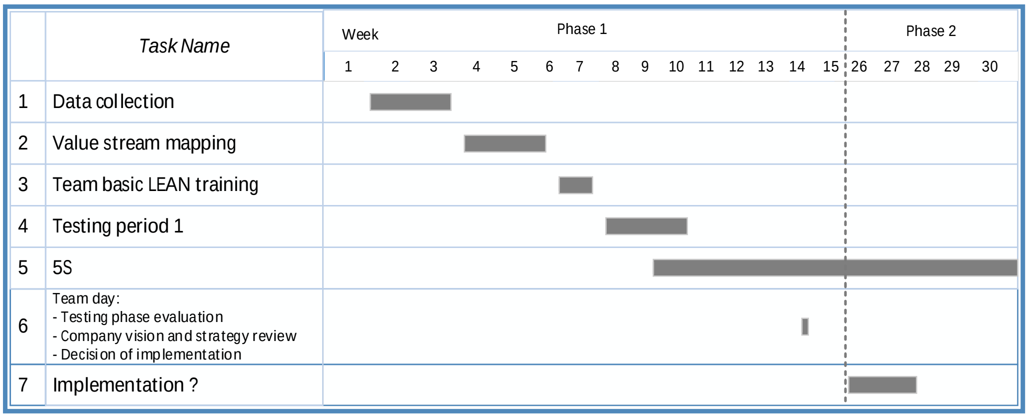


Figure 18. Work plan of the development project

First phase was planned to include:

- data collection
- value stream mapping
- basic training in lean thinking
- selecting of lean "tools" (e.g. 5S, Kaizen)
- planning of rough process structure based on value stream mapping
- testing period

Evaluation of phase 1's results, value stream maps and possible implementation decision were planned to be carried out on the team day. Possible and detailed implementation of the new quotation process was left to be planned in phase 2. The actual implementation of the new process model (phase 2) was left out of the scope of this study.

5.2 Data collection and analysis

After the project preparation, data analyzing could be started. Existing statistics from the previous years was available and it was decided to analyze data from the years 2011-2013.

An average of 12 500 internal quotation inquiries (IQIs) is received yearly by a 10 member sales support team that means five IQIs a day for one engineer. 7,5 hours working time per day gives takt time of 1,5 hours to complete an IQI. However, due to a variety of inquiries takt time calculation is not appropriate for current IQI process. Further study wanted to be made in order to get the time usage in details inside the process.

Takt time calculation will be more applicable inside the new segmented process model introduced further. As the takt time is an essential part of pull guided production, the process could not be designed at this stage to support pull system.

To get detailed time consumption data for each step done for the inquiries, a manual data collection template was created. Processing times for each step were collected by sales support engineers into a Microsoft Excel form (appendix 3). Processing times indicate the work time available to complete one task of the process, e.g. to find out the price of a product, or to get a confirmation reply to an internal inquiry from the engineering. The Excel template contained the main tasks of the quotation process, and the meaning was to add a time stamp once a task starts and once it ends.

However, collecting of processing times was hard and time consuming due to variety of inquiries and engineers' heavy workloads. Moreover, engineers understood the instructions differently which meant that the collected data wasn't comparable. The manually gathered data gave some indication of the time used to various work steps, but a reliable analysis of the data could not be done.

A third method was to use the existing statistics from the sales IT-system. Existing statistics gives general data from quotation process performance. Lead times of IQIs and internal inquiries were gathered and used in inquiry categorization and process segmentation phases. Lead time of an IQI in this study means the time interval between sales support team receiving an IQI and returning a completed quotation back to the sales office. Lead time of an IQI includes the opening time that is the time that an IQI waits before taken under work.

Additionally, lead times of internal queries to the support functions were collected. Internal query lead time means time interval between sales support engineer sending a query to a support function and receiving a completed reply.

Existing statistics replaced the data which wasn't possible to gather manually from the process.

5.2.1 Lead times of the IQIs

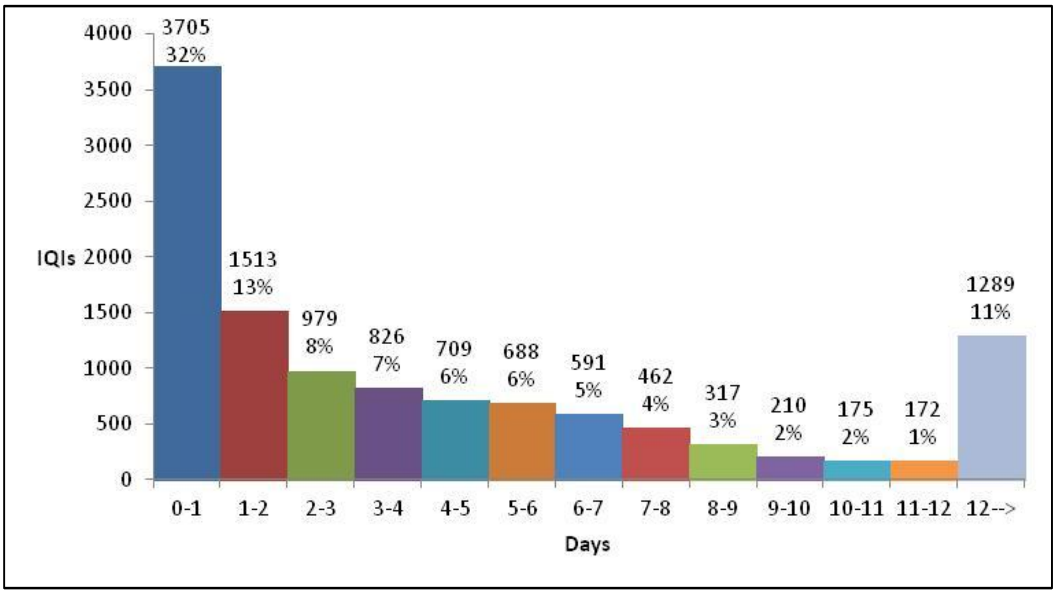
In the data analyzing, it was decided to use previous year's (2013) statistics (table 1). In the year 2013, 11 636 IQIs were received by the case company's sales support team. Average lead time for one IQI was 5,1 days and standard deviation of IQI lead time was 7,8 days. In this study, standard deviation was selected to represent the variance in IQI lead times. Average opening time (the time that IQI is waiting to be processed) of IQIs in the year 2013 was 2,1 days.

Table 1. Key figures of year 2013

Number of IQIs (2013)	Average IQI lead time	Average IQI opening time	Standard deviation of IQI lead time
11636 pieces	5,1 days	2,1 days	7,8 days

Next, a histogram of internal quotation lead times categorized by days (0-14 days) was created (graph 1).

Graph 1. A histogram of internal quotation inquiry (IQI) lead times

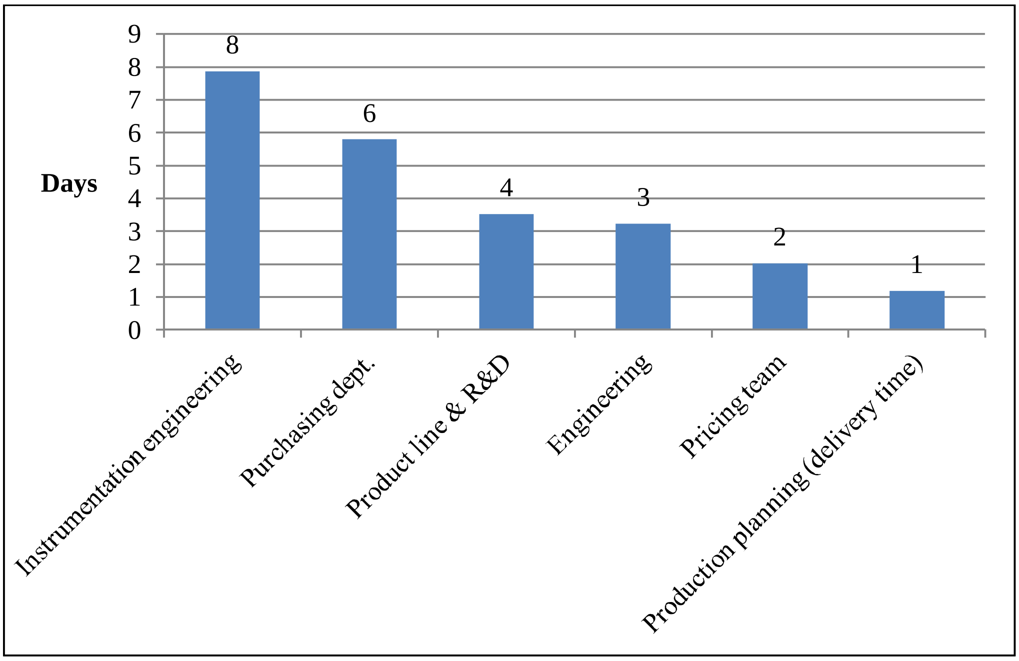


In the year 2013, third of the IQIs were finalized in one day and almost half of the IQIs (32% + 13% = 45%) were finalized in 2 days. The histogram showed that categorizing of the IQIs would be appropriate.

5.2.2 Lead times of the internal queries to the support functions

Next, the lead times of the internal queries to the support functions were collected. Average internal query lead times are shown in graph 2.

Graph 2. Internal query lead times in 2013



Graph shows that the longest reply times to internal queries (average of 8 days) appear between sales support and instrumentation engineering function, whereas a reply to price and delivery time queries is received in 1-2 days.

5.2.3 Current state value stream map and wastes

After the lead time data collection and product categorization, current state value stream map (VSM) was created (figure 19 & appendix 4). Figures and modeling have been adapted from the theory (Keyte & Locher, 2004) (Rayon, et al., 2013) (VSM mapping icons explained in appendix 5).

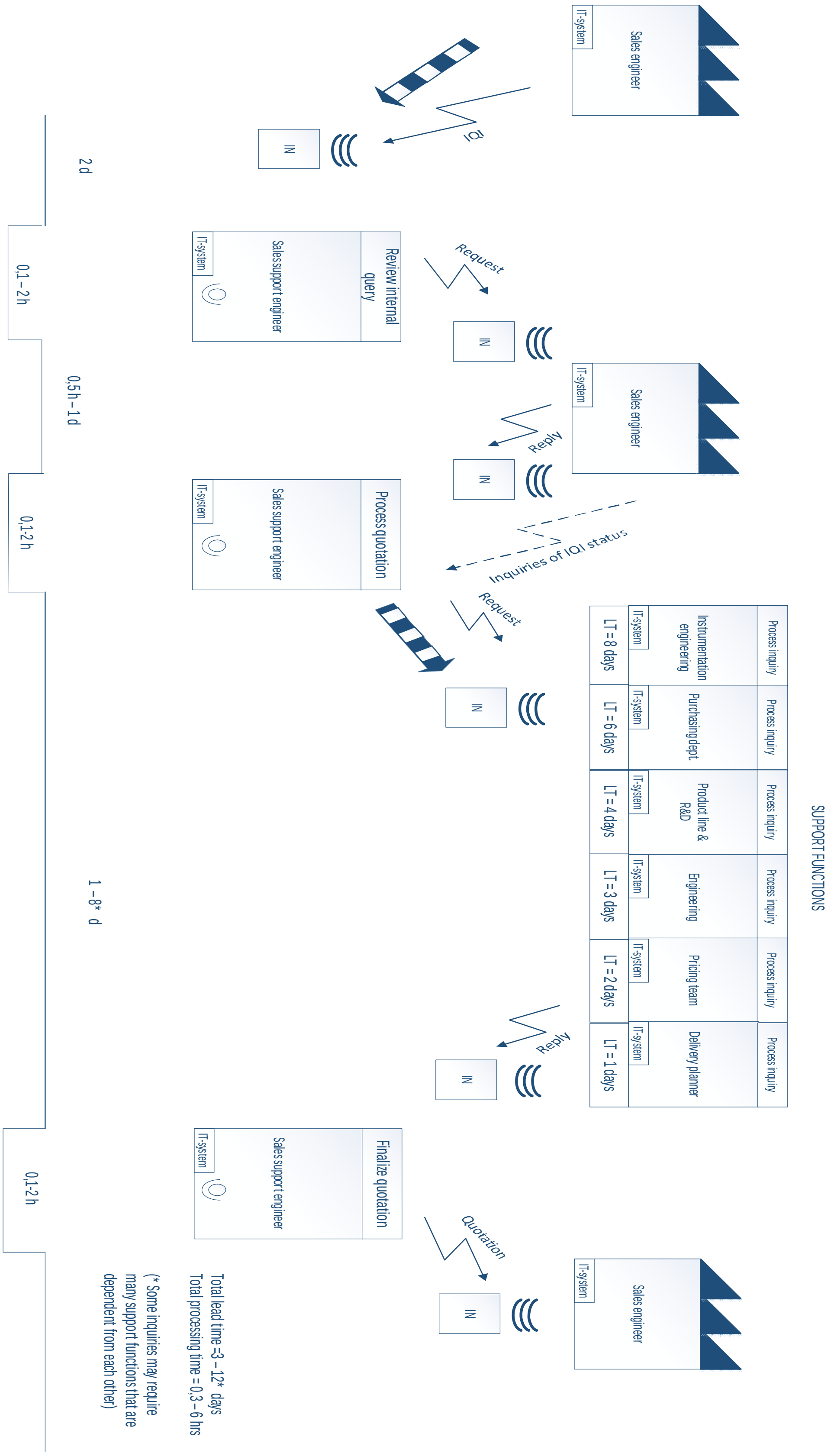


Figure 19. Current state value stream map

The collected lead times have been added on the map. Processing times have been evaluated, since reliable processing time data of the work tasks wasn't available. Current state VSM was analyzed and waste could be recognized.

WASTES in current quotation process

- ***Waiting***

From the "deadly wastes" presented by the theory, *waiting* is by far the most distinguishing waste in the current quotation process. Large range of tasks and duties, including training of new engineers and substituting the absent engineers, create unbalanced workloads among the sales support team. Workloads cause waiting waste especially on opening phase of the process. Regardless of the type of an IQI, an average waiting time of an unopened inquiry in the year 2013 was 2,1 days, 40% of the total IQI lead time (5,1 days). Figure 20 shows the average part of the waste caused by only waiting an IQI to be processed.

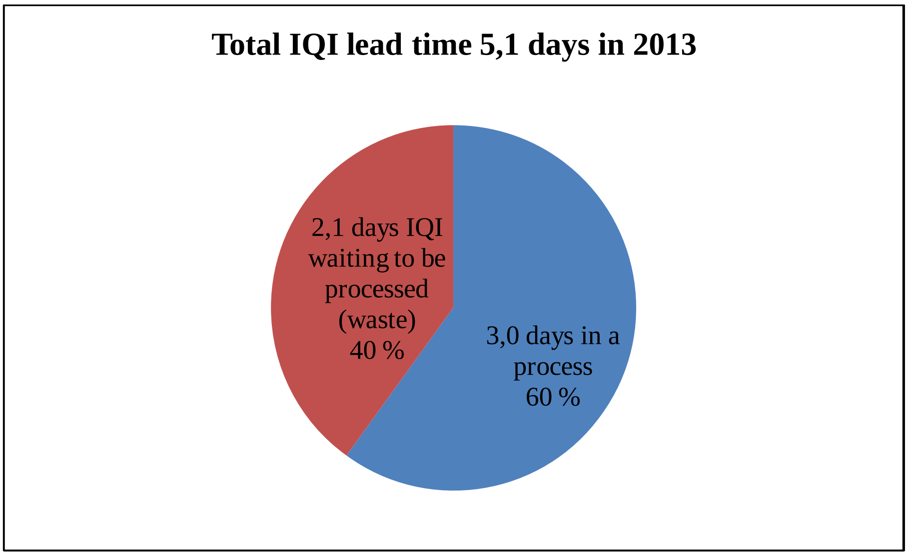


Figure 20. Waste caused by waiting an IQI to be processed

An example of measuring the process efficiency

Process efficiency can be evaluated with an example of measuring value added time of the work which is done for one IQI:

Approximate lead time of an IQI in the year 2013 was 5,1 days. First 2,1 days IQI waits to be processed. Then, a sales support engineer reviews the IQI which takes approximately 20 minutes. If support is needed, internal inquiry is sent to a support function. Once a support engineer has available time, he/she opens the internal query and uses another 20 minutes to reply the inquiry. Next, once the sales support engineer has available time, he/she reviews the reply and uses next 20 minutes finalizing the quotation. 5,1 days (7,5 hours/day x 5,1 days = 38,25 hours) of lead time contains one hour of value added time and the rest is waiting time (waste). Consequently, the process efficiency of an example IQI is 1h/38,25h = 2,6%. Picture 21 shows the value stream in the example IQI.

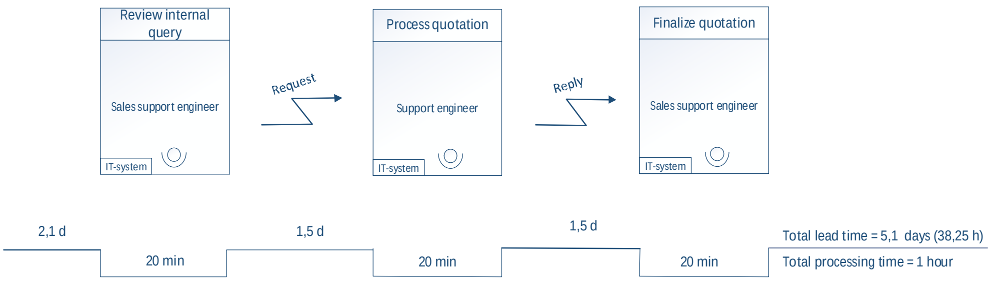


Figure 21. The value stream in example IQI

However, due to a variety of IQI content, reliable measuring of value added time is not possible. For instance, difficult IQIs require more work. Yet, an example of value added time measurement gives an idea of the quotation process efficiency in the case company, and shows the need for a development.

- ***Inspection (sorting waste)***

Another waste which was recognized was a waste of *inspection*. Sales support engineers “scan” their open inquiries many times a day which is waste. As an example, if every engineer uses one hour every day to sort the IQIs, ten hours *inspection* waste occur per day in the current quotation process. Scan is required in order to select the easier IQIs to be processed earlier.

Inspection waste occurs also when IQIs have imprecise information when received and reviewed. IQIs can’t be processed before requesting more information from a sales office.

Moreover, reminders from the sales offices cause waste of *inspection*. Uncertainty and variation in quotation respond times cause pressure in the sales offices. They want to know the status of the IQI and thus use phone, e-mail or online chat in order to remind about the deadline. One reminder may easily cause 15 minutes of interruption in work that is waste.

- ***Inventory and storage***

Waste of i*nventory and storage* was found as well. There are number of databases containing enormous amount of information. Searching of information is often really slow.

- ***Correction and rework***

Sales support engineer works with large range of inquiries from many different countries. Therefore variety of inquiry quality is large. Different ways of working in the sales offices and within the sales support team cause errors and misunderstandings. IQIs need to be revised and corrected which is waste.

5.3 New process model

The gathered data and the current value stream map were analyzed by the sales support manager and the assistant engineer. Because of an unbalanced, long and wasteful quotation process, totally new approach was taken in order to improve the process flow.

First, in order to balance the process, the IQIs were planned to be categorized in product families: easy IQIs (A) and more complex IQIs (B&C). After that, separate process queues were planned for the categorized product families. A-type of IQIs were designed to be processed from the beginning to the end in one queue. B- and C-type of IQIs were designed to be processed in another queue. Next, the process was decided to be segmented into pieces, creating separate desks to process a part of an IQI. Finally, lean tool 5S was planned to be used in order to clean the databases and to standardize the work.

Improvement needs were added on the current state VSM (figure 22 & appendix 6).

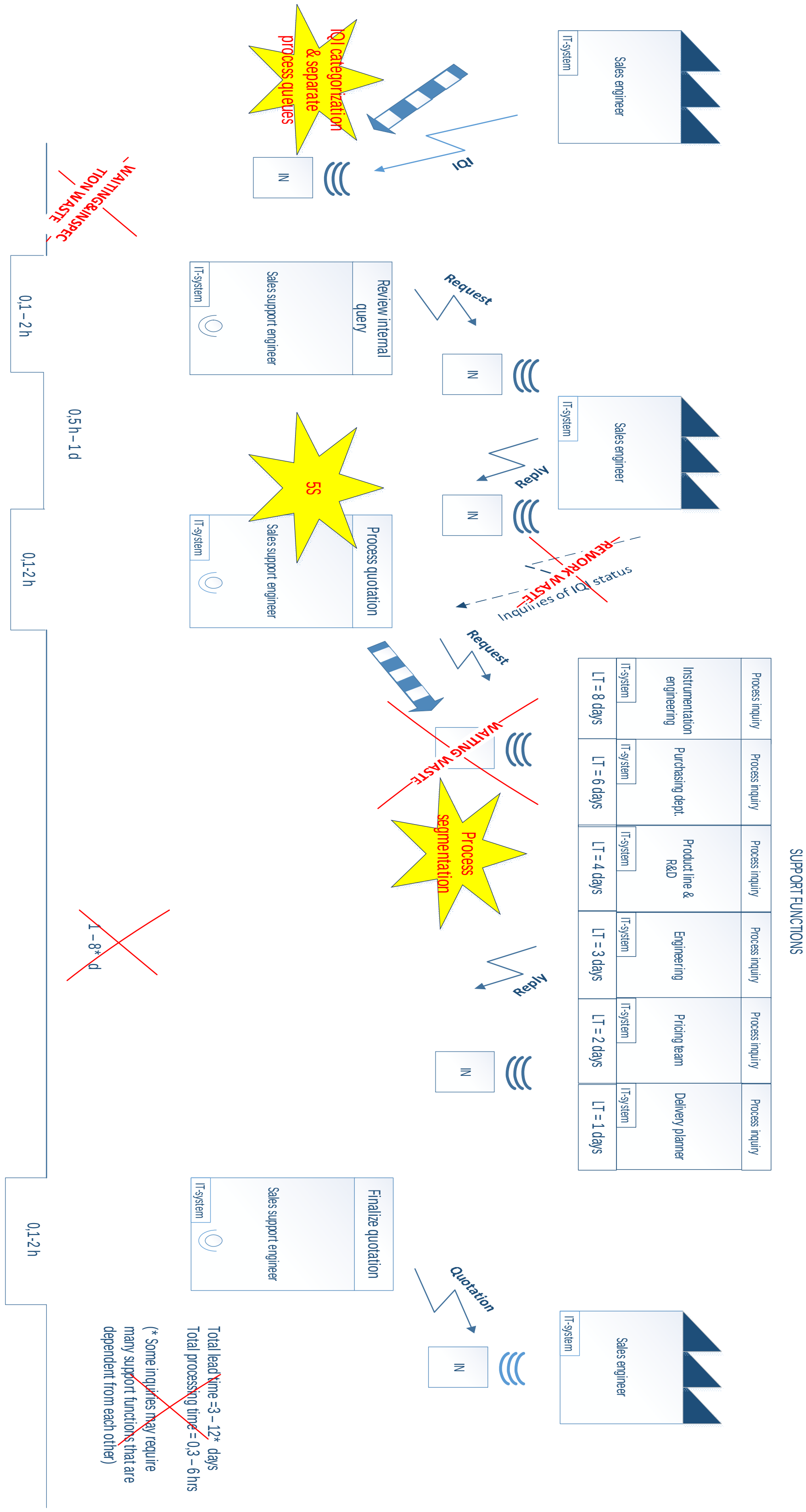


Figure 22. Current state value stream map with improvement needs

5.3.1 Inquiry analysis and a product family categorization (A,B,C)

IQIs can be, in manufacturing terms, seen as partially finished goods waiting for completion. IQIs could be categorized into product families according to the lead times collected. However, queries needed to have a deeper analyze in order to understand the reason for a variance in the lead times. Therefore it was agreed to collect and analyze IQIs of one week (294 pieces) from the previous year 2013 (table 2), and based on this analyze, to categorize the IQIs in product families.

Table 2. One week's IQI analyze (2013)

Inquiry content	Count of IQI	Average of Lead time
Price&delivery time	76	3
IQI update	30	3
Delivery time (asked from support function)	23	4
Price&del. (asked from support function)	51	5
Engineering / typing	11	5
JB (3rd. Party)	11	6
Instr. Component	26	7
3rd party	15	11
Product management	16	15
Instrumentation	22	17
Engineering / materials	13	18
Total	294	

The analysis showed that more than third of the inquiries (36%) required only basic activities which could be finished independently by the sales support engineer in short time (table 3). Basic activities include price check from internal price lists or ERP system, delivery time check from the database, and updates or revalidations of old IQIs. The average lead time of this type of IQIs on one week's data collecting period was three days. This part of inquiries was selected as a product family A.

Table 3. Product family A

Inquiry content	Count of IQI	Average of Lead time
Price&delivery time	76	3
IQI update	30	3

A-family
36% of IQIs
3 days average lead time

Other inquiries required support functions' help. It was decided to select another two families; B and C. B-family consists for example of inquiries of instrumentation components which need to be asked from the instrumentation engineering, or 3rd party products which need to be asked from the purchasing department. According to the selected one week's statistics, B-family considered 41% of the inquiries and average lead time was 6 days (table 4):

Table 4. Product family B

Delivery time (asked from support function)	23	4
Price&del. (asked from support function)	51	5
Engineering / typing	11	5
JB (3rd. Party)	11	6
Instr. Component	26	7
3rd party	15	11

B-family
41% of IQIs
6 days average lead time

C-family consists of more special requirements which need technical or political support from the engineering or the product management (e.g. new products), or of complicated instrumentation content inquiries. C-family selected from one week's data analyzed consisted of 23% of IQIs with the average lead time 17 days (table 5).

Table 5. Product family C

Product management	16	15
Instrumentation	22	17
Engineering / materials	13	18

C-family
23% of IQIs
17 days average lead time

With the help of the product family categorization, process segmentation was easier to be planned and future state value stream map to be created, as presented further.

5.3.2 Separate process queues for the IQI families

As a result of the inquiry analysis and product family categorization, it was decided to create two separate process queues for the selected product families. Simple A-type of IQIs will be processed in one queue and more complicated B- and C-type of IQIs in another queue.

Target of creating separate queues was to ease the predictability of the IQI lead time. For example, A-type of IQIs could be promised to be ready in 1-2 days, B-type of IQIs in 2-4 days and C-type of IQIs in 4-9 days. This would decrease the *inspection* waste caused by unnecessary status inquiries and deadline reminders from the sales offices.

5.3.3 Process segmentation by the desks

Inquiry analysis showed the need for a process segmentation. B- and especially C-type of inquiries are complicated and often require clarification in several different engineering area. Thus, instead of one engineer handling large range of inquiries, it was logical to divide the process in pieces. Teams or “desks” were designed for handling certain specific areas of the inquiry.

Benefits of the “desks”

Desks concentrate only on their specific tasks, that balances the work and decrease waste caused by a rush. Working on one desk may be monotonous compared to the current work. Thus, desk responsibilities were planned to be rotated in every two weeks in order to avoid frustration caused by similar repetitive work. Job rotation also improves learning and helps to develop multi skilled engineers. Particularly training of new engineers becomes easier, since it’s possible to learn one task at a time instead of trying to absorb the whole scope of duties. Job rotation also enables introducing of easier desks to organization’s other employees. External help may be needed in order to reduce the workload during the absence of sales support engineers.

One benefit of a desk is also that similar repeated inquiries can be recognized faster and standardized solutions for them can be created. Future state VSM next will introduce the created desks.

5.3.4 Future state value stream map

Future state value stream map was created according to planned improvement needs. Future state VSM shows the new process flow (figure 23 & appendix 7).

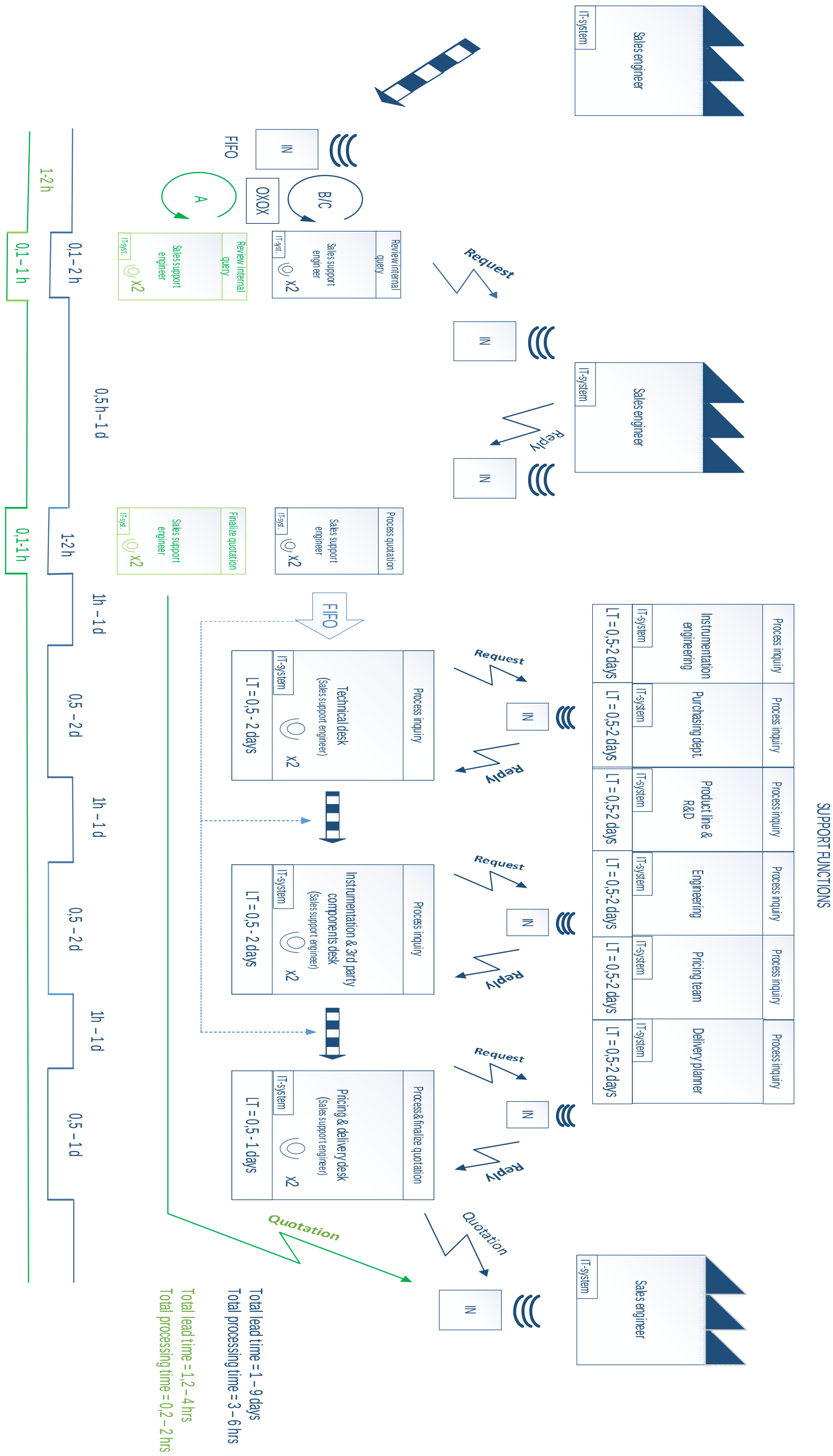


Figure 23. Future state value stream map

With the help of inquiry categorization results, five desks were created to process IQIs; two opening desks and three support desks.

- ***Opening desks***

Opening desks (figure 24) (2 engineers / desk) first take IQIs under work from open box by FIFO (first-in, first-out) rules and review and categorize them. One desk reviews A-type IQIs, and the other desk reviews B- and C-type of IQIs.

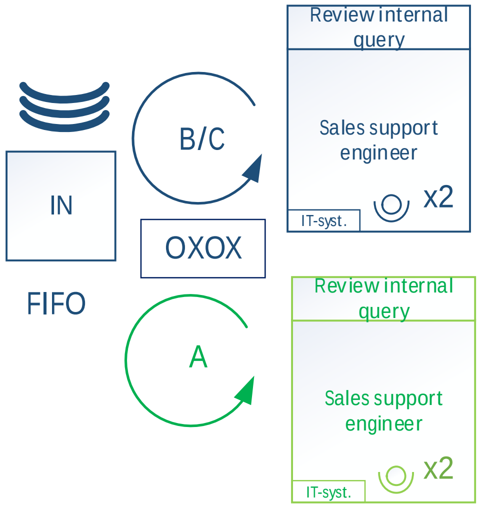


Figure 24. Opening desks

B- and C-type of IQIs are sent forward to a related support desk. B/C-desk's responsible engineer categorizes an IQI in B or C type, and creates a work flow template for the support desks with requirements (figure 25).

Queue (sender initials)

A	
B	
C	XYZ

Needed support fuctions

	Technical desk	Instrumentation & 3rd party products- desk	Price & delivery desk
Request	Valve materials?	3rd party product?	Price and delivery time for the products?
Desk's comments (initials)			

ITEM 1: VALVE - 3rd PARTY ACTUATOR

Figure 25. Work flow template with requests

The template states which desks will need to work on the IQI and what is required from each desk. The review phase is completed, once the IQI is moved to the queue of the first support desk e.g. technical desk.

Opening desks concentrate only on opening, reviewing and finalizing IQIs. Due to two opening desks, IQIs will be opened quicker than during the old process.

- ***Support desks***

Support desks (figure 26) (2 engineers / desk) process B- and C-type of inquiries. Roles of the support desks were selected according to similarity of inquiry contents and lead times, and by gathering current support functions' roles together by a desk:

1. Technical desk
2. Instrumentation and 3rd party components- desk
3. Pricing and delivery desk

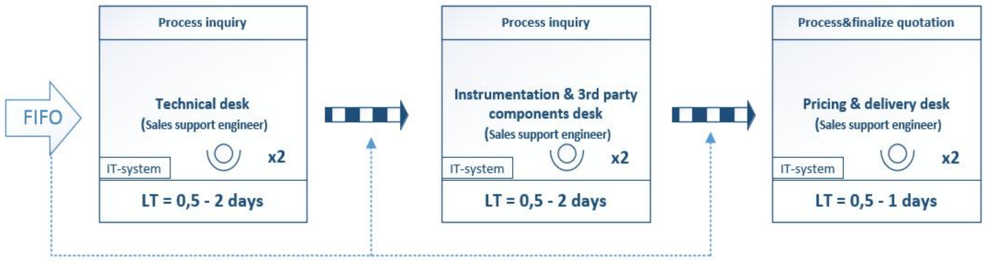


Figure 26. Support desks

1. Technical desk

Technical desk handles queries regarding technical and political matters considering the products manufactured by the case company. Technical desk uses support from product line (product managers), engineering and R&D departments. Technical desk's responsibility is to confirm the product selection, validity and availability. The desk's responsible engineer enters correct products and details in the IT-system and adds comments on the template sent by the opening desk (figure 27).

Queue (sender initials)

A	
B	
C	XYZ

Needed support fuctions

	Technical desk	Instrumentation & 3rd party products- desk	Price & delivery desk
Request	Valve materials?	3rd party product?	Price and delivery time for the products?
Desk's comments (initials)	Materials checked. XZY		

ITEM 1: VALVE - 3rd PARTY ACTUATOR

Figure 27. Work flow template with comments from the technical desk

Once everything is corrected, inquiry can be sent forward to the next needed desk, the instrumentation and 3rd party desk (example template) or the price and delivery desk.

2. Instrumentation and 3rd party components- desk

The instrumentation and 3rd party components- desk works with inquiries related to instrumentation matters, as well as inquiries of the products which have to be purchased from the external suppliers. Support is asked from the company's instrumentation and purchasing departments. The desk's responsible engineer adds correct products and components in the IT-system with comments (figure 28) and sends IQI forward to the price and delivery desk.

Queue (sender initials)

A	
B	
C	XYZ

Needed support fuctions

	Technical desk	Instrumentation & 3rd party products- desk	Price & delivery desk
Request	Valve materials?	3rd party product?	Price and delivery time for the products?
Desk's comments (initials)	Materials checked. XZY	3rd party model xxx-xx-xx offered. ZXY	

ITEM 1: VALVE - 3rd PARTY ACTUATOR

Figure 28. Work flow template with comments from the instr.&3rd party products desk

If price and delivery time check is not needed, engineer finalizes the quotation and sends it back to the sales office.

3. Price and delivery desk

The price and delivery desk finds out prices and delivery times for the products. Support is asked from pricing engineers or the factory's production planners. Once the prices and delivery times are added into the system, engineer completes the request template (figure 29), rechecks the IQI and finalizes the quotation.

Queue (sender initials)

A	
B	
C	XYZ

Needed support fuctions

	Technical desk	Instrumentation & 3rd party products- desk	Price & delivery desk
Request	Valve materials?	3rd party product?	Price and delivery time for the products?
Desk's comments (initials)	Materials checked. XZY	3rd party model xxx-xx-xx offered. ZXY	Ok. Added to system. YXZ

ITEM 1: VALVE - 3rd PARTY ACTUATOR

Figure 29. Work flow template with comments from the price & delivery desk

The order of the support desk is dependent on the previous desk. For example, technical validity of the product (type codes, materials) needs to be confirmed before the price check. If an IQI requires processing from many of the support desks (e.g. C-type of inquiries), it flows efficiently forward through the desks, instead of having to send it back to opening desk to be rechecked and reprocessed like in the current quotation process.

The support desks concentrate only on their particular tasks and they may process queries without the help of support functions.

5.3.5 Work plan for testing phase

After the data collection, product categorization, process segmentation planning and value stream mapping, the case study was at the point where the testing phase could be started. Planning and preparation of the testing event was conducted by the sales support manager and the assistant engineer. Planning and preparing phase follows somewhat similar order as Kaizen event planning, introduced by the theory;

- ***Motives and goals***

Motives and goals for the planned new process model and lean thinking were first discussed together with the team. Target of the new process model was to reduce the variance in IQI lead times and in quality, balance the workload of the engineers and ease the positioning of the new engineers.

- ***Training***

Basic training about lean and its tools and methods were given to the team by the sales support manager. Training contained basics of lean philosophy, e.g. 14 principles, 8 wastes, value added thinking, continuous improvement and the lean tools like 5S, value stream mapping and SMED.

- ***Schedule and target of the testing event***

Next, the schedule and the target of the testing event was agreed with the team. Important factor was that all engineers can participate on 9 days (7 work days, 2 days off in the weekend) testing. Also members of the support functions were invited. It was agreed that one of the instrumentation engineers would join the event every day for a while as a help. The key target of the testing event was to test whether the product categorization and process segmentation works in the quotation process in general, as well as how the new process flows between the desks.

- ***Place***

The place of the event, large meeting room, was booked from the same building as a work office. The meeting room provided the needed supplies and materials like big screen and white boards for group activities. Also catering services (breakfast) were booked for the days of the testing period. A day before the testing period started, sales support team was told to move all necessary working tools to the testing area. The sales support manager and the assistant engineer prepared the desks of the tables and chairs of the room (figure 30).

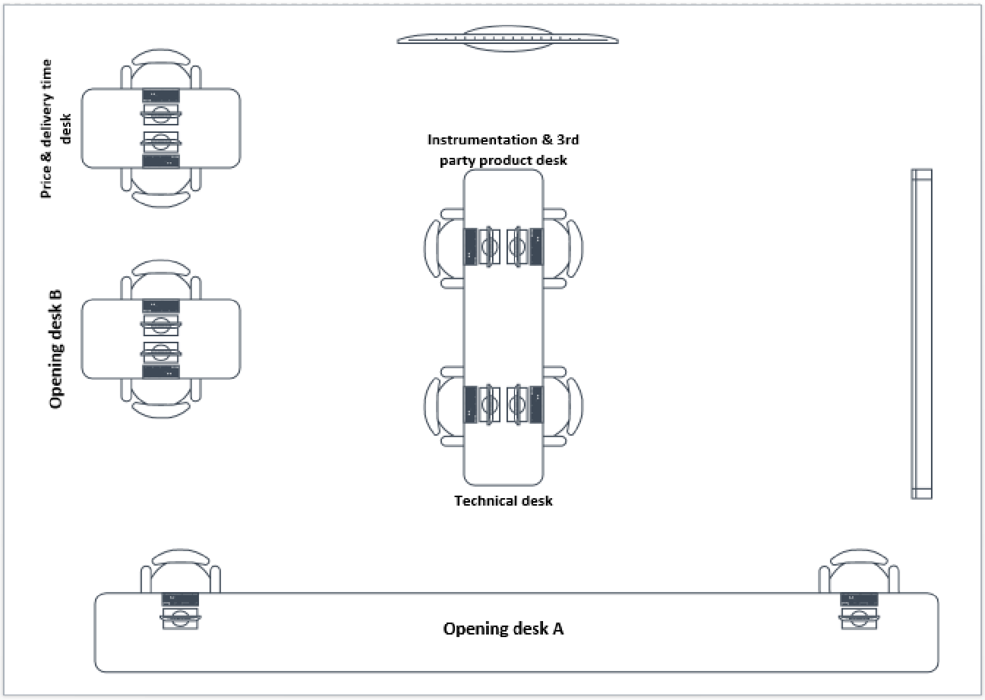


Figure 30. Testing area

Teams were nominated for every desk and a name list was attached on the wall (figure 31).

Figure 31. Name list by the desks

Status table (figure 32) was created in order to show the status of the IQIs to the team every day. Status table counted the number of open and under work (WIP) IQIs and finished quotations. The purpose of the status table was to visualize the current status for the process members.

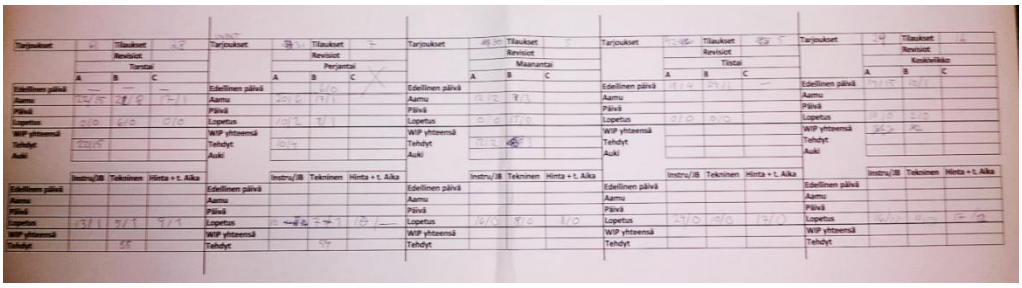


Figure 32. IQI status table

5.4 Testing period

The testing period started with a meeting where the schedule of the testing was reviewed and work tasks were agreed together with the engineers. Next, every engineer transferred all their open IQIs to sales support manager's inbox. Total 89 open IQIs were categorized into inquiry families A, B and C by the team (table 6):

Table 6. Open IQIs in the beginning of the test day 1

IQI Type	A	B	C
Quantity (pcs)	37 (42%)	34 (38%)	18 (20%)

Ratios of categorized IQI quantities were approximately same as in collected one week's data from the previous year.

After the inquiry categorization, team started to process the IQIs. The team adjusted relatively quickly to new process and after a while process started to flow somewhat fluently. Process flow is shown on figure 33.

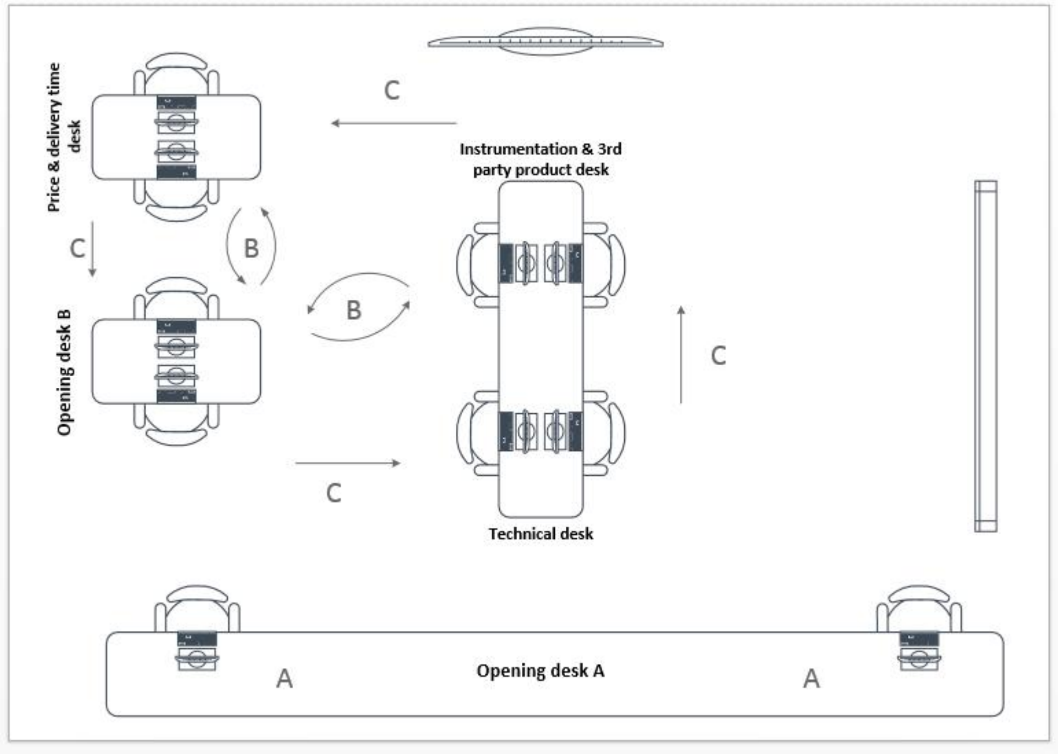


Figure 33. Process flow on testing period

The status was summarized at the end of the day; only 6 IQIs were unopened of initial 89 IQIs (table 7):

Table 7. IQIs unopened at the end of the 1. day

IQI Type	A	B	C
Quantity (pcs)	0	6	0

And 30 IQIs were under work by the support desks (table 8):

Table 8. IQIs under work at the end

Desk	Technical	Instrumentation & 3rd party products	Price & delivery time
Quantity (pcs)	6	14	10

New IQIs which received on the first testing day were not added on the results. Yet, the output of the first testing day was encouraging; 93 % (83 pcs) of the IQIs were opened to be processed on the same day and 60% (53 pcs) were finished on the first day. Statistics of the rest of the testing period are shown in appendix 8.

5.4.1 Statistical results of the testing period

After the testing period, statistical results were analyzed by the sales support manager. 336 IQIs were opened and 363 IQIs were finished during the 9 days period. A reason that more IQIs were finalized than opened during the period is that engineers had some IQIs under process when the testing period started.

Average quotation lead time during the testing phase was 4,6 days with standard deviation of 7,0 days. Average opening time of IQIs in the testing period was 1,8 days. Table 9 summarizes the figures within the testing period.

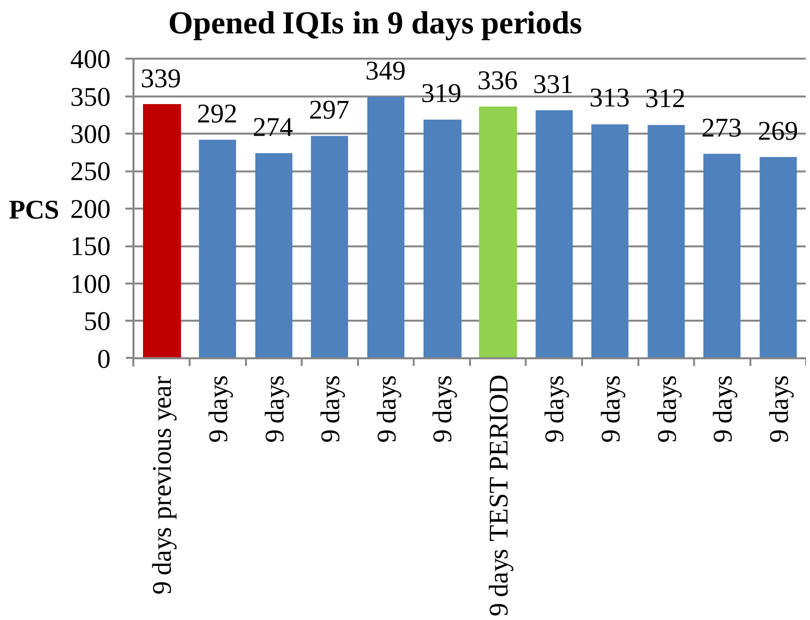
Table 9. Results from the testing period

Opened IQIs	Finished IQIs	Average IQI lead time	Average IQI opening time	Standard deviation of IQI lead time
336 pcs	363 pcs	4,6 days	1,8 days	7,0 days

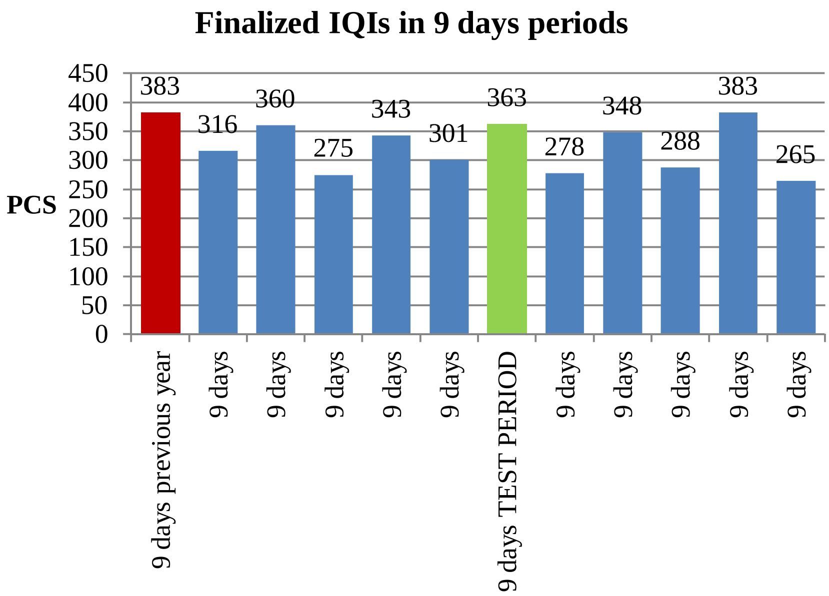
To get a more exact view of the testing period, the results were compared to similar 9 days (7 works days, 2 days off) period from the same time previous year, as well as 9 days periods (5 periods) before and after the testing.

The amount of opened (336 pcs) and finished (363 pcs) IQIs during the testing period was on good level compared to the similar periods (graphs 3&4).

Graph 3. Opened IQIs during the testing period compared to other similar periods

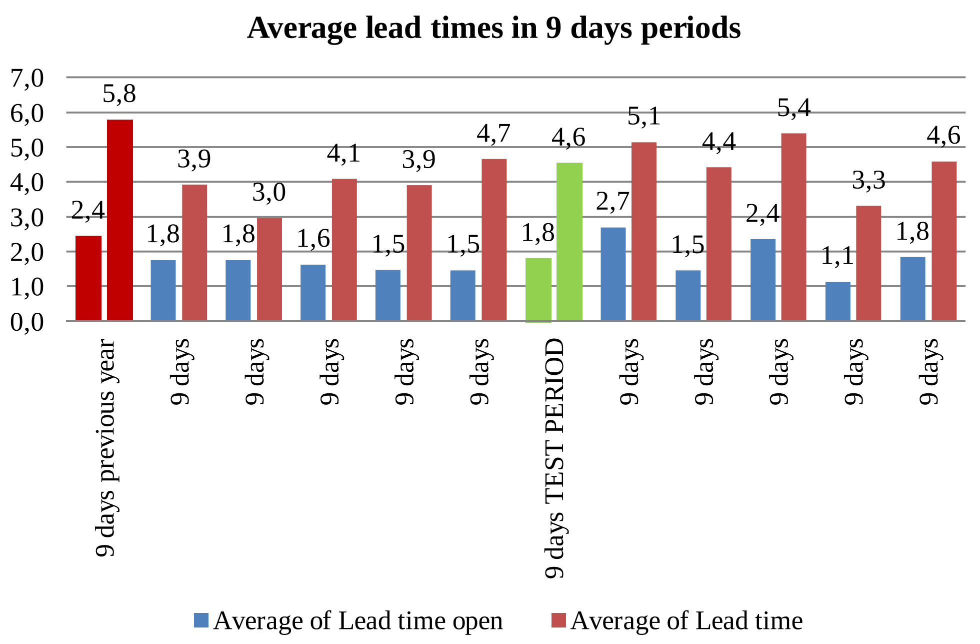


Graph 4. Finished IQIs during the testing period compared to other similar periods



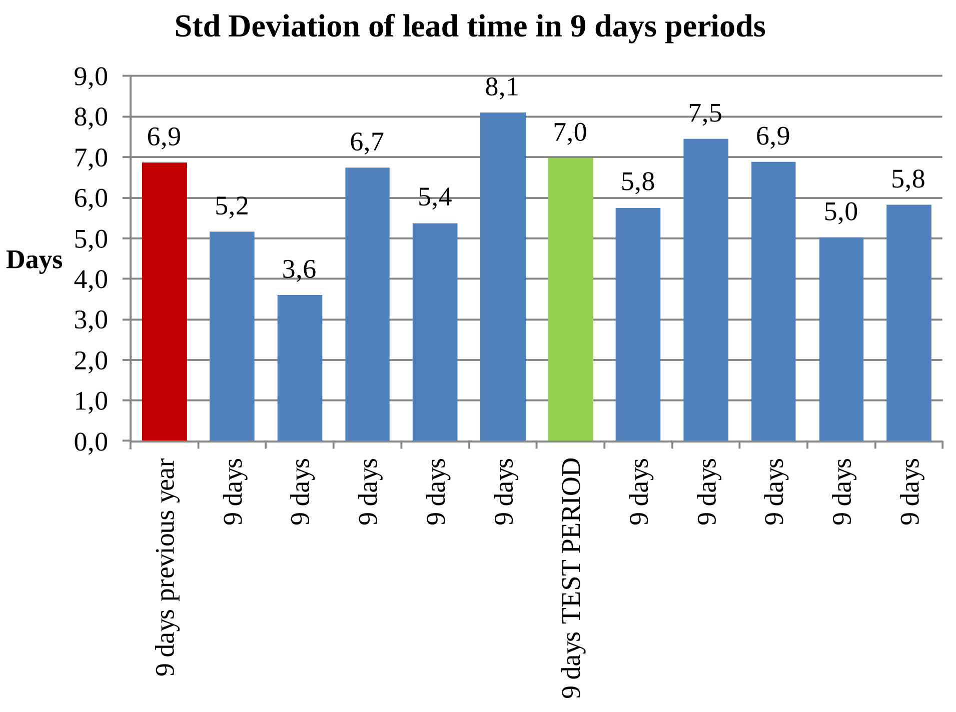
An average lead time (4,6 days) and an average opening time (1,8 days) (graph 5) were on approximately same level as in the periods before and after the testing, but on good level compared to the previous year's period.

Graph 5. Average lead times during the testing period compared to other similar periods



A standard deviation of the lead time during the testing period (7,0 days) was on approximately the same level as during the all compared periods (graph 6).

Graph 6. Standard deviation of the lead time during the testing period compared to other similar periods



In sum, the statistical results of the testing period didn’t change remarkably compared to the other similar periods. However, taking into account that sales support team first needed to learn the whole new process, the output was promising. Moreover, responsibilities changed daily during the testing period that caused waste. Besides, the testing period was executed with improper tools (laptops instead of double screens and without own desktop tools) that slowed down the work. Therefore, the testing period can be considered successful with the good results.

5.4.2 Benefits of working together

During the testing period, it was noted that the communication between the engineers was continuous that speeded up the work due to reduced time of information search from databases. Better communication also decreased the external support need. Moreover, communication and teamwork enhanced the team spirit.

New ideas and feedback about the process and responsibilities came up continuously from the engineers and ideas were noted on the whiteboard. For example, after the first day C-type of IQIs were not separated anymore. There was no sense to separate C-type of IQIs because they hold resources from B-type of IQIs and vice versa. Similarly, easier B-type of IQIs were agreed to be processed by A-type of IQI opening desk.

Testing period showed that working is more effective when engineers work closely together, cooperate and help each other. Thus, it was decided to reconstruct the current office layout in the near future in order to improve the communication between the engineers. In the current quotation process, engineers work at their own work desks.

5.4.3 Team day

A few weeks later, the testing period was summarized and the results were introduced to the sales support team in a special overnight team day event arranged by the sales support manager. Testing period was evaluated and everyone was able to give feedback of it. Majority of the engineers were satisfied with the new process but similarly some resistance arose. In the end, it was voted that the new process model would be taken into use.

5.5 5S / Office clean up

In order to standardize the work in the quotation process, lean method 5S was planned to be taken into use. The method was introduced to the sales support team during the testing event and it was agreed that 5S-meetings would be arranged every week. First 5S-meeting was arranged right after the testing period. Team discussed the purpose of the cleaning and decided that the most important criteria to clean were computer work desks and information databases. Physical office clean up could take place once the new process and possible new lay out is taken in to use.

- **Computer work desks**

  Every engineer used to work with own kind of work desks displaying databases used during the years. A work desk could contain number of currently unnecessary databases (figure 34) that made it slower to find the needed ones.

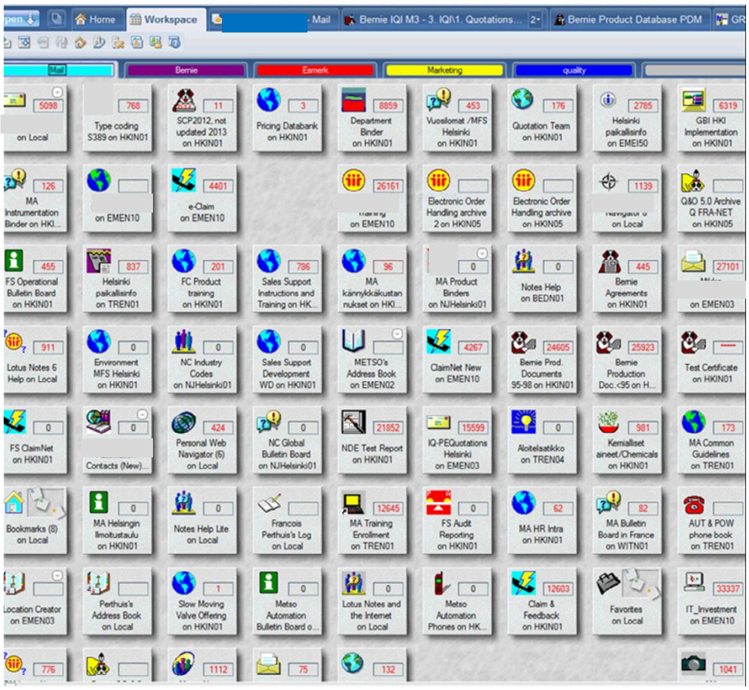


Figure 34. Work desk before 5S

Sorting (1.S) assignment of work desks was given to a group of engineers who went through all the existing databases from their work desks and evaluated the importance of them. As a result, only needed databases were left on the work desk and the proposal of the new work desk layout was given to the whole team. After a discussion and setting the databases (2.S) in order, standard database was taken in to use of every engineer (figure 35).

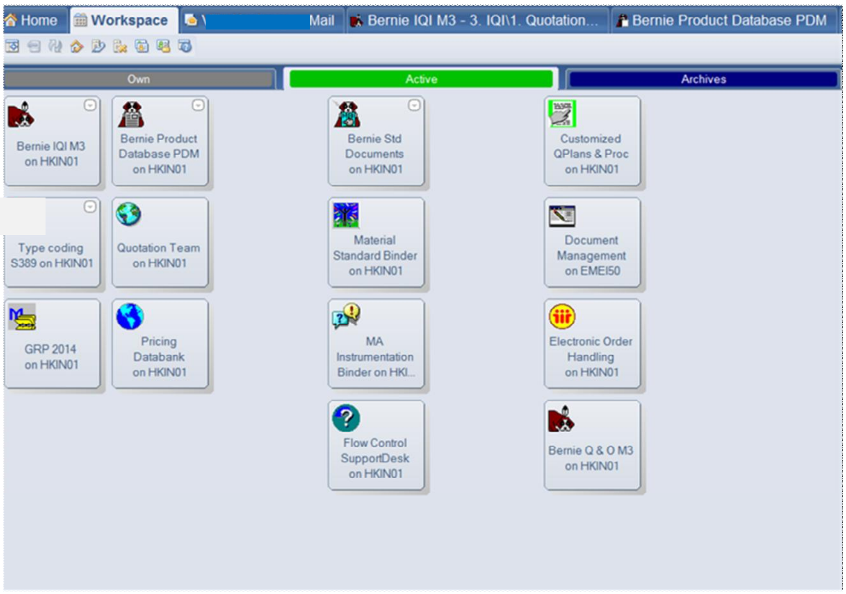


Figure 35. Work desk after 5S

The picture of new standard database was added into a quotation team database (4.S), introduced next, and every engineer agreed to independently clean and sustain the own work desk (3.S & 5.S).

- **Quotation team database**

Another work tool which needed to be cleaned was engineers every day used mutual database – *quotation team* – containing the most essential instructions needed to prepare quotations. Again, 5S task was given to a group of engineers, who sorted out (1.S) the instructions, agreed about them with the rest of the team, set them in order (2.S) and cleaned the view (shine, 3.S). Database was taken in to a standard use (4.S) after the first three S and the responsible engineer was nominated to sustain it (5.S). New or old instructions to be added or removed are discussed by the team in a weekly 5S-meeting.

6. RESULTS

Today, lean is a management system applicable to all organizational interactions (Smith, 2013, p. 44). The purpose of this study was to find out whether lean tools and methods are applicable in a quotation process. This chapter answers the research questions set in the beginning of the thesis.

6.1 Are lean tools and methods applicable in a quotation process?

The main research question of this thesis was:

Are lean tools and methods applicable in a quotation process?

The case study showed that at least some of the main **lean tools and methods are applicable in a quotation process and they can bring benefits into the process**.

With the help of related literature, lean training and the case company's lean experience, we selected the proper lean tools and methods to be tested in the case company's quotation process. The testing showed that the chosen tools and methods were somewhat easily implemented into the quotation process. The preliminary statistical results showed that the lead times remained on a good or on a better level than in the current quotation process.

6.2 The usage of lean tools and methods in the quotation process

The problem statement was:

What kind of lean tools and methods can be used in order to balance and standardize the quotation process and reduce the variance in quotation lead times and in quality?

The theory introduces numerous lean tools and methods to improve the office processes. The most suitable ones (bolded below) were selected to be utilized on the case study. First, inquiries were categorized by a **histogram**. The histogram showed that **categorizing** the IQI's into **product families** (A, B, C) is appropriate and needful due to the large range of inquiry topics and variance in quotation lead times.

Next, the process wastes:

- *waiting*
- *inspection*
- *inventory and storage*
- *correction and rework,*

were identified with the help of the **value stream mapping**. Waiting turned out to be the most apparent waste in the quotation process.

Then the quotation process was segmented into desks (**office cells**) by **leveling production**. Case study showed that the method leveling production balanced the workloads of the sales support engineers. Working in the desks helped to concentrate on one special area of the inquiry. The quality of the quotations was considered to be improved, when the stress, caused by handling the whole wide scope of the inquiry, reduced. Process segmentation was also considered to help in training of new engineers and in substituting absent engineers, as the work was divided into smaller portions.

5S method was applied for work standardization. Sales support team cleaned the work desks, which speeded up the information searching time. Engineers started to use same tools what was considered to improve and balance the quality of the quotations.

The selected tools were tested in nine days testing period (**Kaizen event**) which was carefully planned beforehand by the sales support manager and the assistant engineer. Testing period was considered beneficial among the sales support team, since it showed that the selected lean tools and methods are suitable and work in the quotation process. Testing period, executed in one open area, showed the benefits of the cooperation by the engineers.

Takt time calculation and **SMED** tools were not applicable at the testing phase. Takt time calculation was too difficult due to a variety of inquiries and heavy workloads. When the takt time was not utilized in the process, also pull guided process with single peace flow could not be implemented. 5S was considered to replace SMED at the testing phase.

Matrix (table 10) shows which tools and methods were presented in this thesis and which ones were decided to be tested and implemented on the case study.

Table 10. Lean tools and methods introduced and tested in this thesis

Lean tools & methods	Thesis	Implementation
Leveling production	x	x
Product categorization	x	x
Value stream mapping	x	x
Takt time	x	
Histogram	x	x
Kaizen event	x	x
5S	x	x
SMED	x	
Office cells	x	x

Statistical results during the testing period were approximately on the same, or even on the better level than during the current quotation process. However, statistical results from such a short testing period can't be considered reliable enough. Yet, statistical results can be considered indicative. The results of the testing event gave enough information to the sales support team to decide to move to the new lean based quotation process model.

6.3 The benefits lean tools and methods bring to stakeholders in the quotation process

Another problem statement was:

What benefits lean tools and methods bring to stakeholders in the quotation process?

Following benefits were identified during the planning and testing phase:

- **Sales support engineer**

By process segmentation and work standardization, sales support engineers have clear rules how to process every task. Engineers can concentrate on one task that reduces the rush and pressure of the work. Balancing the workloads also make substitution of absent engineer simpler. Furthermore, training of new engineers is easier and learning is faster. These changes increase the employee satisfaction.

- **Sales support team**

Within new process model, there is more time to work on other tasks than quotations. These are for instance meetings, trainings, preparing procedures, quality plans etc., tasks which are necessary but create no value to customer. In addition, continuous development of the quotation process itself is easier.

New process model also enhance communication between engineers. This and better employee satisfaction increases the team spirit.

- **Sales offices**

Sales offices receive quotations in predictable time and they can tell customer when they can respond to RFQ. Quality of quotations is better that reduces a need for further inquiries from the sales support team, and improves the communication with customers. Due to a faster customer response and a better quality of quotes, more orders are likely received.

- **Customer**

Faster and more accurate respond to customer requests is considered to increase customer satisfaction.

Table 11 summarizes the benefits that the stakeholders of the new quotation process receive.

Table 11. The benefits for the stakeholders of the new quotation process

	Sales support engineer	Sales support team	Sales office	Customer
BENEFITS	Less rush & pressure	More time for other necessary tasks	Better predictability to quote	Increased satisfaction
	Easier substitution	More time for process development	Better quality of quotations	
	Easier training	Better communication	Less rework	
	Faster learning	Better team spirit	Better communication with customer	
	Better employee satisfaction		More orders	

7. CONCLUSIONS

Increasing demand of rapid and accurate quotes showed the need of developing the case company's old quotation process. The quotation process in the case company in this thesis was unbalanced, leading to wide variance in quotation lead times and in quality. Workloads were burdening sales support engineers, who process the quotations, and training of new engineers was slow and heavy. The key target of this study was to find out if lean tools and methods could be applied in order to balance the quotation process.

A substantial amount of literature about lean philosophy was found and reviewed to be utilized for this study. Most of it still refers to manufacturing processes, but researches about lean in service industries and office processes have lately become more common. Furthermore, some recently conducted studies about using lean tools and methods in a quotation process were discovered.

As a result, the objective of this thesis was met; planning a new process model, and testing of it with the sales support team, showed that at least most of the lean tools and methods are applicable in the quotation process and they help to balance the workloads of the sales support engineers and variance in quotation lead times and in quality.

Furthermore, testing of the new model showed the benefit of the cooperation. Team spirit rose, which was seen to improve the satisfaction in the work. Most likely the better team spirit also improved the motivation and the efficiency of the sales support engineers.

Although the new quotation process model was proved to be beneficial, changing the way of work generated some resistant in the sales support team. Especially the more experienced engineers were skeptical about the new model. Yet, the resistance against the change can be considered natural.

Future considerations and discussion

Lean thinking is based on continuous improvement. As Womack and Jones stated in their book (2003, p. 260):

When you've fixed something, fix it again.

Most of the tools and methods used in the case study can be reused with the new quotation process. The testing showed that working together is beneficial, thus the layout change would be the first thing to fix in the future. Currently every engineer has an own work desk (figure 36).

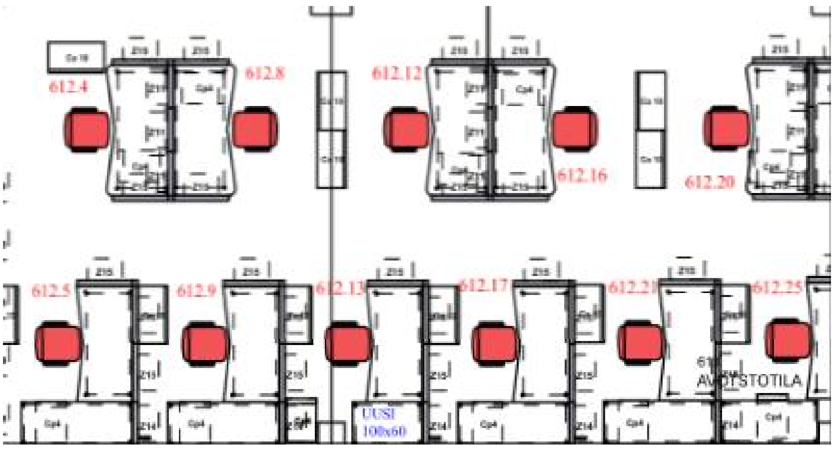


Figure 36. Current office layout of the sales support team

The integration of the two work desks into one work desk, like in figure 37 for example, could improve cooperation and bring benefits to the process.

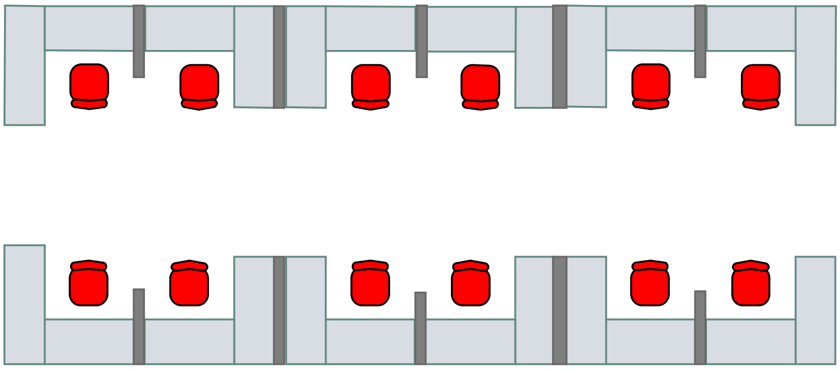


Figure 37. An example of the future office layout of the sales support team?

There are also numerous other lean tools that could be considered to be studied and tested with the new process model in the future. In fact, the new lean based quotation process is easier to be developed than the old process.

One future target could be to reduce the item amount of inquiries by lean method **reduce lot size / one piece flow**. IQI would be easier to handle if it contained only similar products, only from a same product series for instance. Currently one IQI may contain many different product series with many different requirements. Case company's order receiving department uses *one piece flow* already.

Another target would be to create lean method **pull system** inside the process flow. Using pull system could be potential when the new lean based process has been implemented. Especially takt time calculation which was tested in the case study could be easier in pull system.

Nevertheless, lean philosophy is far more than improving a process. Lean is a culture based on continuous improvement and respect for people. At the moment, the case company is using a lean toolbox in order to improve the process. The future will show if and how lean thinking in general is adopted by the sales support team in order to sustain continuous improvement. The future will also show if other organizations, for example sales offices, can be introduced on lean thinking. Working together and better communication would help to eliminate more waste from the processes and generate more value to customers.

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Appendix 1 Example of request for quotation (RFQ)

Industrial Services

REQUEST FOR QUOTATION

Page: 1

To :
Attn. :
Fax No :
Your Ref. :
Our Ref. :

Date :June 02,2014

Please quote for the following.

Line	Item No	Description	Quantity
1		CONTROL VALVE WITH ACTUATOR COMPLETE SIZE/DIMENSION: 10" (DN250)RF RATING : 300LB MODEL NO: FUNCTIONAL CAPACITY SHOULD BE EQUIVALENT TO OLD VALVE	1
2	ACTUATOR	ACTUATOR , COMPLETE FOR CONTROL VALVE VALVE SIZE/DIMENSION: 10" RATING 300 LB VALVE MODEL:	2
3	BALL	402331511 BALL FOR	1
4		CONTROL VALVE WITH ACTUATOR COMPLETE SIZE/DIMENSION: 16" RF MODEL NO:	1
5	SEAT RING	SEAT RING FOR SIZE/ DIMENSION: 16" RF MODEL NO:	2
6	BALL	402335161 BALL	1

Appendix 2 Example of internal quotation inquiry (IQI)

CASE COMPANY

12.06.2014

Internal Quotation Inquiry

Dear Quotation Engineer,

Please check the price and delivery for the valve.

Br.

Sales Engineer

Latest reply for this inquiry: 14.06.2014
Contact Person: xxxxxxxx
Reason Code: Price & Delivery
Sales Office Ref.: xxxxxxxx
Customer name: xxxxxxx

P.O. Box
xxxxx yyyy
Kuwait

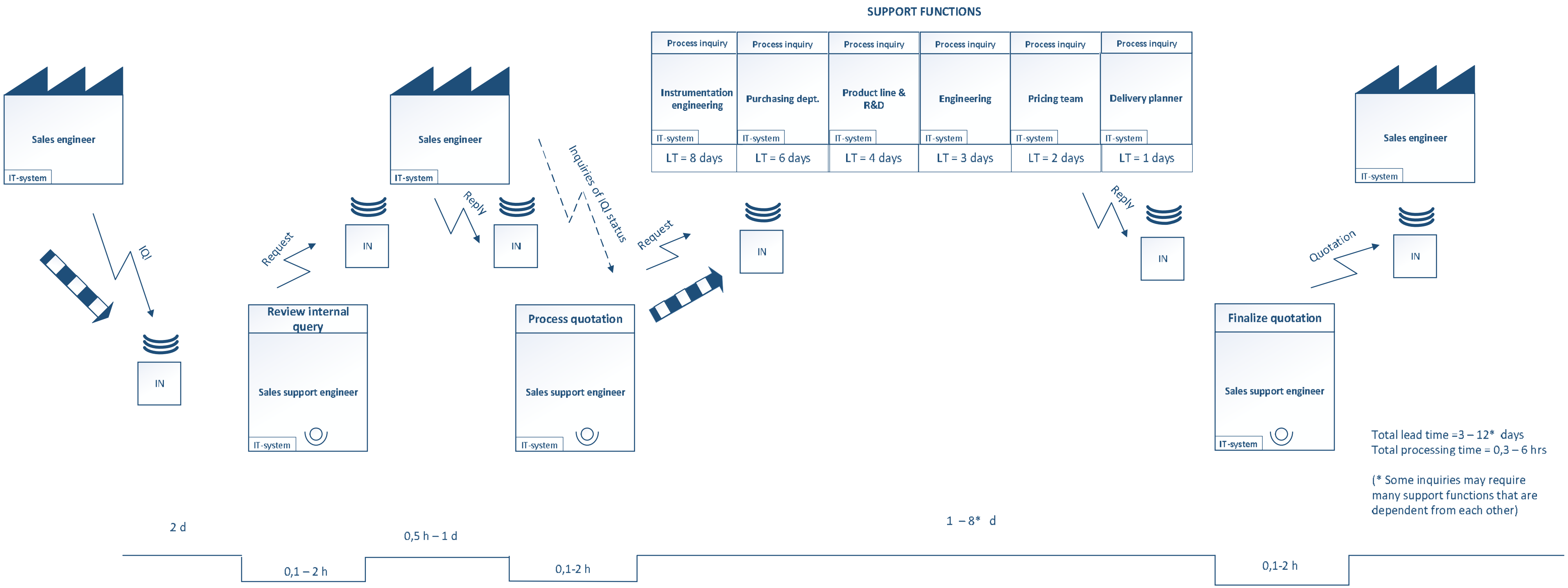
XXX-HV-8101-XXX

0001 VALVE-ACTUATOR-POSITIONER-INSTRUMENTATION

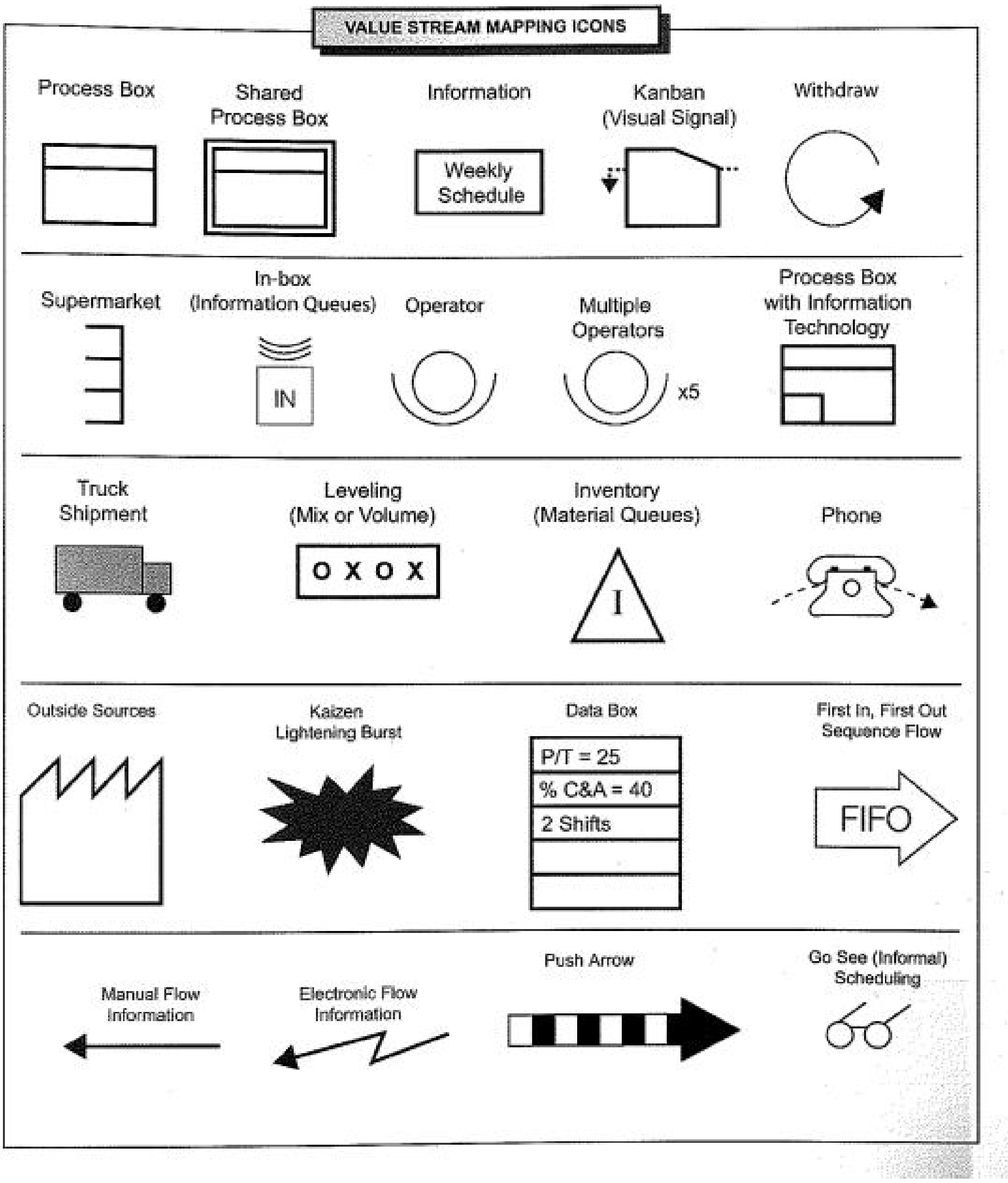
Appendix 3 Processing time excel

	D	F	G	H	I	N	O	P	Q	R	S	T	U	V	W	Z	AA
1																	
2																	
3	Basic			Task													
4		Under work	Ready	Material clarificatio		Product management		Engineering		3rd party products		Instrumentation		Delivery Time		Pricing	
5	IQI nr.	Time	Time	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
6	FI130019ViK F	18.7.13 10:00	22.7.13 16:15														
7	FI130076ViK	18.7.13 10:01	18.7.13 13:11											18.7.13 13:08	18.7.13 13:11	18.7.13 12:28	18.7.13 13:07
8	FI130077ViK	18.7.13 14:57	22.7.13 14:10									18.7.13 15:32	22.7.13 13:51				
9	FI120144TTS I	18.7.13 16:16	18.7.13 16:25													18.7.13 16:10	18.7.13 16:25
10	FI130083PA R	19.7.13 9:12	24.7.13 13:00					30.7.13 13:30	30.7.13 14:08								
11	FI130078ViK	19.7.13 13:16	19.7.13 15:06	19.7.13 13:19	19.7.13 13:32											19.7.13 14:33	19.7.13 15:04
18	FI130087ViK	23.7.13 12:39	24.7.13 9:38														
19	FI130085ViK	23.7.13 12:47	23.7.13 15:55													23.7.13 13:16	23.7.13 13:40
20	FI130074ViK F	24.7.13 12:59	8.1.13 8:52														
21	FI130397PA F	24.7.13 13:02	24.7.13 13:10														
22	FI130088ViK	24.7.13 14:29	29.7.13 16:01			25.7.13 10:10	26.7.13 13:43									26.7.13 13:45	29.7.13 16:01
23	FI130089ViK F	24.7.13 15:59	25.7.13 11:27			24.7.13 16:07	25.7.13 11:20										
24	FI130090ViK F	24.7.13 16:00	24.7.13 16:27														
25	FI130092ViK	24.7.13 16:30	26.7.13 15:47			24.7.13 16:33	26.7.13 15:28										
26	FI130091ViK	25.7.13 10:20	25.7.13 10:49									25.7.13 10:20	25.7.13 10:40				
27	FI130350PA R	25.7.13 10:58	8.8.13 13:14							25.7.13 15:44							
28	FI130179PA R	25.7.13 11:07	26.7.13 15:42											25.7.13 12:10	26.7.13 15:42	25.7.13 11:10	26.7.13 9:41
29	FI130093ViK	25.7.13 11:14	6.8.13 13:15									25.7.13 14:00	2.8.13 13:16				
30	FI130094ViK	25.7.13 14:24	2.8.13 11:13									25.7.13 14:30	25.7.13 14:59	25.7.13 14:59			
31	FI130095ViK	25.7.13 14:29	1.8.13 12:44											25.7.13 15:33	1.8.13 12:44		
32	FI130096ViK	26.7.13 10:54	26.7.13 10:56														
33	FI130097ViK	26.7.13 10:57	26.7.13 13:13														
34	FI130064ViK F	26.7.13 13:15	29.7.13 15:47	26.7.13 13:15													
35	FI130335PA R	26.7.13 13:48	26.7.13 13:49											26.7.13 13:49	26.7.13 13:49		
36	FI130098ViK	26.7.13 14:15	26.7.13 14:54									26.7.13 14:16	26.7.13 14:52				
37	FI130099ViK	26.7.13 15:50	29.7.13 17:02			26.7.13 15:51	29.7.13 16:02										
38	FI130100ViK	29.7.13 10:22	8.1.13 9:47														
39	FI130101ViK	29.7.13 10:23	2.8.13 13:18													29.7.13 12:45	2.8.13 13:05
40	FI130102ViK	29.7.13 10:24	6.8.13 13:20													29.7.13 12:45	6.8.13 13:20
41	FI130103ViK	29.7.13 10:25	30.7.13 16:05														
42	FI130104ViK	29.7.13 12:46	29.7.13 16:16														
43	FI130092ViK F	29.7.13 12:48	30.7.13 16:26			29.7.13 12:56	30.7.13 16:25										

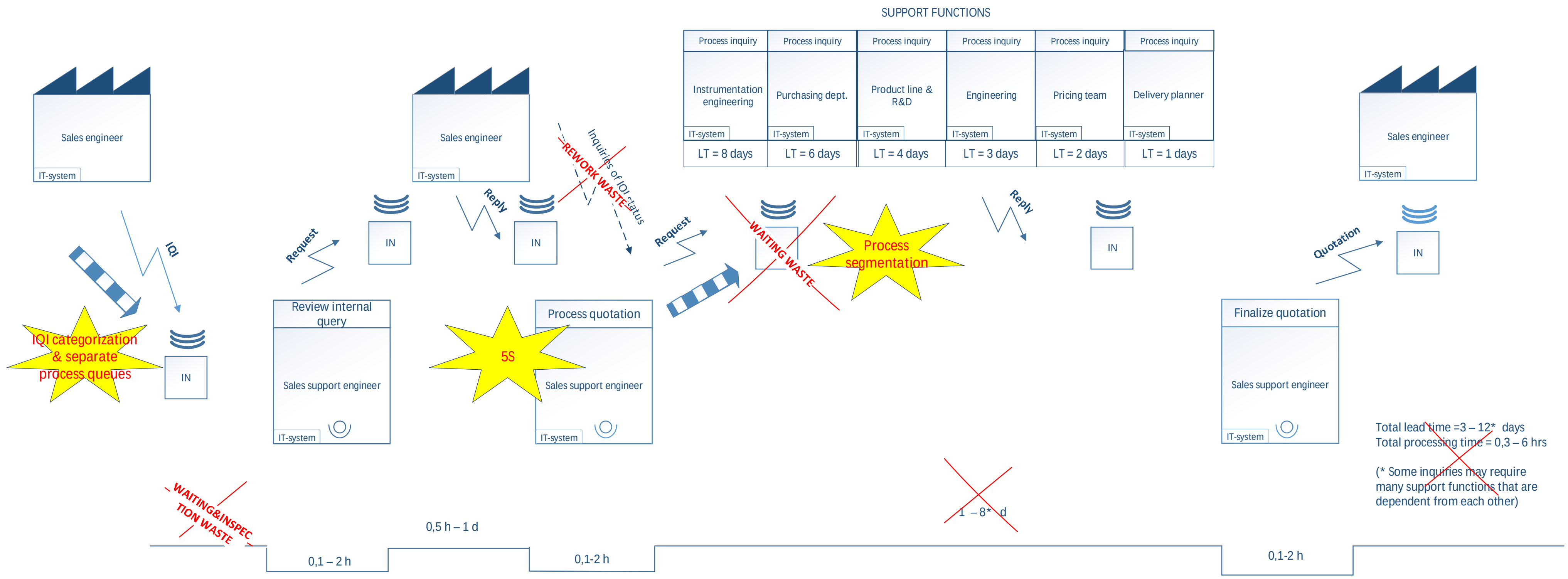
Appendix 4 Current state value stream map



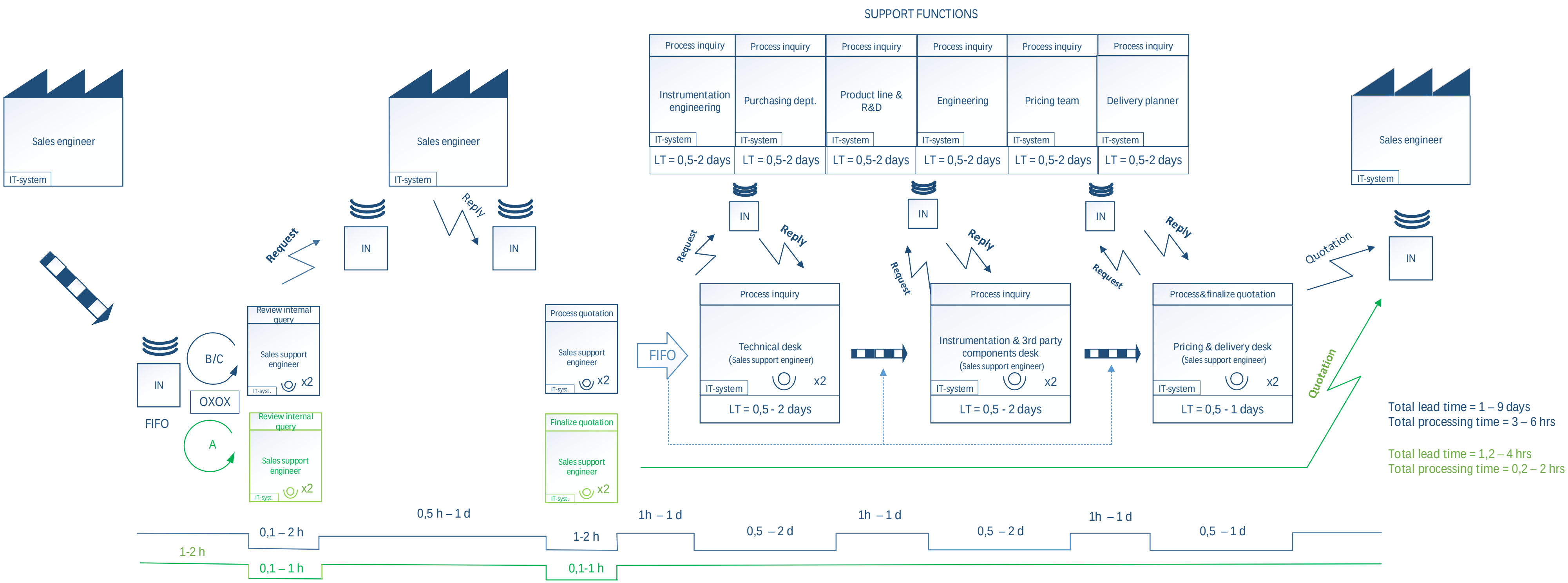
Appendix 5 Value stream mapping icons (**(Keyte & Locher, 2004)**



Appendix 6 Current state value stream map with improvement needs



Appendix 7 Future state value stream map



Appendix 8 IQI status table during testing period *

Day	2			3			4			5		
IQI Type	A	B	C	A	B	C	A	B	C	A	B	C
Open (start)	36	24	-	14	16	-	22	35	-	24	16	-
Unopened (end)	12	9	-	0	15	-	0	0	-	10	2	-

Desk	Technical	Instrumentation & 3rd party products	Price & delivery time
Day 2	10	8	2
Day 3	16	8	8
Day 4	24	10	17
Day 5	16	11	19

*= Testing period lasted 9 days, but testing area was booked only for 5 days. Status table was updated in testing area only