List of abbreviations

VSM:	**V**alue **S**tream **M**apping
SCM:	**S**upply **C**hain **M**anagement
TPS:	**T**oyota **P**roduction **S**ystem
FIFO:	**F**irst **I**n **F**irst **O**ut
5S:	**S**ort, **S**et in Order, **S**hine, **S**tandardize, **S**ustain
MRP:	**M**aterials **R**equirements **P**lanning
MRP II:	**M**anufacturing **R**esources **P**lanning
ToW:	**T**able **o**f **W**aste
CSM:	**C**urrent **S**tate **M**ap
FSM:	**F**uture **S**tate **M**ap
EOQ:	**E**conomic **O**rder **Q**uantity
JIT:	**J**ust **i**n **T**ime
TQC:	**T**otal **Q**uality **C**ontrol
WIP:	**W**ork **i**n **P**rocess
C/T:	**C**ycle **T**ime
L/T:	**L**ead **T**ime

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1 Introduction

The chapter will present the background and the problem specification of the study. This has served as the foundation in formulating the problem statement, which in turn will serve as the foundation of the thesis.

The topic of lead time reduction is very hot for companies manufacturing a wide range of products, including those companies which outsource a significant part of their activities to other market players. Analysis of the product flow has thus been an important component in the business decision making process regarding the optimization of the organizational structure, relationships with sub-contractors, suppliers and transportation companies. The topic of this master thesis originates from company HAGS Aneby AB (Here and after it will be referred as HAGS) that produces playing systems comprising numerous components. An attempt to understand and analyze the problems in the product flow of HAGS on the example of one playing system made this study interesting not only from the methodological point of view, but also due to getting acquainted with many practical situations associated with one particular product flow.

1.1 Background

The term Value Stream Management originates from Supply Chain Management (SCM) that typically refers to the entire supply activity of a firm. Nowadays, SCM is "emerging into value activity management, which recognizes the importance of demand in addition to supply" (Marzian, McLaughlin & Andraski, 2003). Bruce et al. (2004) stated that the tendency of value creation usually takes place outside the boundaries of the individual firm. This implies that the practical field of SCM is changing continuously in order to cope with complex and diverse customer demands (cited in Halldorsson, Kotzab, Mikkola & Skott-Larsen, 2007). Companies explore the potential of the concept of SCM to improve their revenue growth by developing lean supply chains. This implies delivering products fast and at a minimum total cost for customers (Gunasekaran, Lai & Cheng, 2008). Lean supply chain integrates all the key processes and partners necessary to deliver the product to the end customer by adjusting the activities to the constantly changing demand of customers while delivering products quickly. As a result, companies that are parts of a lean supply chain become more competitive because they have lower cost than their competitors (Srinivasan, 2004). Wood (2004) stated that Value Stream Management results in the reduction of wasteful activities, which makes the company more responsive to customer demand.

Stalk and Hout (1990) state that the focus on shorter lead time, flexibility and responsiveness of the supply chain links external and internal activities, creating competitive advantage. Companies develop a structure which facilitates inter-company integration, coordination and synchronization of material flow (cited in Rich & Hines, 1997). Inter-company integration and co-ordination focus on the supplier development through long-term partnerships, trust and development of a structured process for information exchange between the organization and its supply chain (Ellram, 1991; Macbeth & Ferguson, 1994; Merli, 1992; cited in Rich & Hines, 1997). Synchronization of material flow originates from the Toyota Production System (TPS) in Japan. The Toyota's lean supply network was characterized by high level of supply-chain integration and a structured approach to managing a smaller number of direct suppliers (Andersen Consulting, 1994; Hines, 1994; cited in Rich & Hines, 1997). The TPS production was based on lean thinking that is the essence of lean production. Lean thinking is grounded on the five principles (specify value, identify value stream, flow, pull, and seek perfection) that are fundamental to the elimination of waste (Hines & Taylor, 2000). A framework of value stream mapping was developed by Toyota in Japan to understand waste and inefficiency in value streams (Jones, Hines & Tich, 1997). According to Brunt (2000), the benefits of removing waste and inefficiency in value streams are realized by showing a big picture of the value stream to optimize rather whole than individual processes. The detailed value stream mapping toolkit can be applied to fill in gaps left by big picture mapping. Some of the detailed mapping tools are process activity mapping, supply chain response matrix, production variety funnel, quality filter mapping, demand amplification mapping, value analysis time profile, and decision point analysis (Hines & Taylor, 2000).

According to Koskela (2004), the five lean principles provide a comprehensive foundation for transformation of productive activity from traditional to lean production. However, there are some limitations in application of lean thinking. Lean thinking is fragmented and lacks an adequate conceptualization of production. Next, the five principles do not systematically cover value generation. In addition, "the failure to trace the origin of lean concepts and principles reduces the opportunity to justify and explain them" (Koskela, 2004 p.35).

The focus of the study lies on leaning the supply chain of HAGS. Considering the lean thinking including the five principles and their limitations, we found them relevant for visualization of the Origo components flow, identification of wastes and looking for the ways to reduce the wastes. In our view the value stream mapping method applied here to Origo components flow could in future be extended to other product flows at HAGS.

1.2 Specification of Problem

The research problem solved in the thesis originates from the practical problem regarding the product flow at HAGS that has to be improved. Preliminary discussions with HAGS in the project formulation phase revealed problems with long lead time causing high level of inventory that were accompanying the product flows of various playing systems. The decision was to visualize and analyze the flow on the example of Origo family components, and then propose possible measures how to improve it. Besides, the lean manufacturing principles including the concept of wastes and associated mapping tools had in many practical situations proven to be an efficient methodology to cope with lead time problems.

The research problem solved in the thesis is thus formulated as follows:

- How can the value stream mapping method be applied for improving the Origo components flow at HAGS?

It was thus interesting to apply lean principles, and particularly the value stream mapping method in the Origo flow context. Additionally, data collection possibilities provided at HAGS, including access to internal documentation, personal communication and contacts with sub-contractors and suppliers, made it realistic to solve the research problem.

1.3 Purpose

The purpose of the study is formulated as follows: *to conduct a case study of the Origo components flow, by combining the lean thinking principles and the data collection methods, and thereby identifying, analyzing and proposing solutions for waste-related problems in the product flow at HAGS.*

1.4 Research questions

In order to fulfil the purpose of the study, the following research questions have to be investigated:

- *How* can the lean thinking framework be applied in searching for wastes in the flow of Origo family components?
- *What* are the reasons for the wastes in the Origo value stream?
- *What* can be done in order to reduce or eliminate the wastes in the flow of Origo family components?

1.5 Delimitation

The single case study was limited to the Origo product components which is the main part of a number of playing systems manufactured by HAGS. Proposing the solutions for waste related problems does not include implementation questions. The solutions were rather specified in terms of *what* can be changed in the internal HAGS organizational structure and their relationships with sub-contractors and suppliers. Only the key subcontractors and suppliers of HAGS were chosen for investigation of the Origo product flow.

1.6 Disposition of thesis

The thesis will henceforth be organized as follows:

Chapter 2	The Frame of Reference presents to the reader the knowledge in the areas of lean production, lean thinking, postponement and positioning the organizations in terms of supplier relations. The value stream mapping method and the detailed mapping toolkit is presented. The theoretical tools presented in this chapter serve to interpret empirical data during the analysis.
Chapter 3	The Methodology describes how the case study is conducted to combine both theoretical and empirical approach. Application of the value stream method is discussed, taking into account the features of the investigated product flow and company specific data collection activities.
Chapter 4	The Empirical Studies present the collected empirical data from HAGS including the order fulfillment process and the main actors involved in the HAGS value stream.
Chapter 5	The Analysis presents the interpretations and reflections derived from the empirical studies by applying the theoretical knowledge. The focus is on the waste identification in the flow of Origo by constructing the current state map. Solutions to reduce the identified are proposed and visualized in the draft of the future state map.
Chapter 6	Conclusions will present the main findings from different perspectives including methodological, theoretical and managerial implications.

2 Frame of reference

The purpose of this chapter is to provide the knowledge on the chosen theories for achieving the research purpose.

2.1 From mass production to lean production

According to Srinivasan (2004), the first automobile manufacturing in the world were two Frenchmen, Rene Panhard and Emil Levassor, who obtained a license to build engines from Daimler in 1889. The next year they had built a car. Since they saw no future in the business they sold the business to Armand Peugeot. More and more car manufactures were establishing in the market in Europe and US. However, all of them had used craft production and cars were produced small volumes.

Henry Ford was the first mass producer in the US who changed the manufacturing world by introducing the concepts of flow and throughput velocity. The aid of the concepts was the moving-assembly line that sharply reduced the assembly time. Ford had a goal to reduce waste not just within the factory but also across the entire supply chain. The removal of waste allowed reducing the production costs that benefited customers. However, Ford incurred high cost from manufacturing details, which cost the company thousands of dollars. Due to the promoting only a standard model with a single color Ford lost the market share to General Motors' Chevrolet. General Motors had modified the principles of mass production and could offer the different models every year (Srinivasan, 2004).

Henry Ford's contribution to mass production was the source of inspiration for many concepts and tools used in Toyota Production System (TPS). In 1960s Japanese manufactures came into the US market when it was the oil crisis hit. The Japanese compact cars used much less fuel than the American large cars. Japanese succeeded due to producing cars at low costs and using just-in-time (JIT) philosophy. They chose an unconventional path to reach greater heights, by beginning the long process of developing and refining manufacturing processes to minimize waste in all aspects of operations (Seth& Gupta, 2005). JIT management system was invented by the two persons, Kiichiro Toyoda and Taiichi Ohno, who worked for Toyota Motor Corporation. Kiichiro Toyoda was inspired from Henry Ford's book *Today and Tomorrow*. He had an idea to produce only what was needed and only when it was needed on a given day. It was introduced the method of kanban that became the basis for the JIT system (Srinivasan, 2004). Kanban is the means of JIT management or signaling system between a corporation and its suppliers. Supplier delivers components to the production line *as* and *when* they are needed (Gross, 2003). Moreover, he saw the need to cooperate with suppliers to perform JIT system and to change the traditional workshop layout to the product layout. The continuous improvement (kaizen) concept was brought from the visiting Ford Motor Company, and the supermarket principle was brought from the visiting the supermarket in US (Srinivasan, 2004). The idea to produce in small batches came up after the visit Ford Motor Company since a manager from TPS realized how wasteful are the production processes in big batches that US auto manufacturers were performing.

Thus it can be said that TPS benefited by introducing Henry Ford's concepts of kaizen (continuous improvement), flow, pull production and waste elimination. The supermarket principle helps in pull production, i.e. to produce when it is needed. Furthermore, TPS emphasized the partnering with the automakers and their suppliers to achieve the mutual benefits (Srinivasan, 2004).

The partnering means the closer collaboration with the key actors in a supply chain. Figure 2-1 shows the essentials of Lean manufacturing cycle.

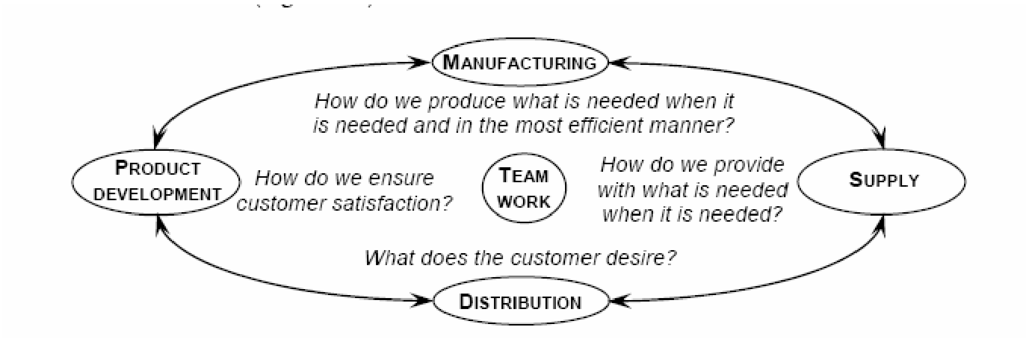


Figure 2- 1The essentials of Lean Manufacturing (source: Björnfot, 2006)

The actors are close connected in every day operations. The production is based on the principle *what* customer needs and *when* customer needs. Other actors in the supply chain balance their work according to the same signal that arises from customer demand. When a customer places an order, the actors start to produce in 'just in time' manner. The central role performs the cross-organizational team work, which coordinates the flow.

The goal of lean manufacturing is to reduce waste in human effort, inventory, time to market and manufacturing space to become highly responsive to customer demand while producing high quality products in the most efficient and economical manner (Seth& Gupta, 2005). This approach centers on the elimination of waste. Waste takes many forms and can be found at any time and in any place, it may be found hidden in policies, procedures, process and product designs, and in operations. Waste consumes resources but does not add any value to the product.

Thus, lean manufacturing combines the best features of both mass and craft production: the ability to reduce costs per unit and dramatically improve quality while at the same time providing an ever wider range of products and more challenging work (Womack, Jones & Roos, 1990). It was established beyond doubt that the organizations that mastered lean manufacturing methods had substantial cost and quality advantages over those, which were still practicing traditional mass production (Fleischer & Liker, 1997).

To sum up, Lean manufacturing was introduced by Toyota Production System that had its roots in the Henry Ford's mass production system. The major emphasis was upon the reducing any kind of waste not even within the company but also across the supply chain. To speed up the production processes the principles of JIT, pull production, continuous flow were emphasized. The methods and tools to fulfill the principles were highlighted such as kanban, continuous improvement (kaizen), supermarkets, production in small batches and changing the traditional workshop layout.

2.2 Lean thinking

The term 'Lean thinking' was coined first by Womack, Jones and Ross in the book of "The Machine that Changed the World" (1990). The goal of lean thinking is to eliminate *muda*, that is, Japanese word for waste. The concept 'lean' is based on JIT principles and they were introduced to describe the working philosophy and practices of the Japanese automobile manufacturers and in particular the TPS (Womack, et.al., 1990). Western automobile manufacturers applied the concept in mass production (Harrison & van Hoek, 2005).

Scholars that research value streams and lean initiatives explored other avenues such as the theory of constraints, system dynamics, simulation, and mathematical and expert system-based approaches (Seth & Gupta, 2005). Their work mainly focused upon the same point: how to minimize inventory and ensure its visibility in the pipeline in different industrial scenarios, and country-specific conditions. Thus, lean thinking has close connections with the above mentioned theories.

Lean thinking can be applied at all levels in a company and across a supply chain in order to eliminate wasteful activities. The two goals can be achieved in eliminating wasteful activities: 1) Lean thinking reduces lead times of products. The benefit will be that a company will be more flexible and responsive to downstream customers and will be able to provide smoother and more predictable demand for upstream suppliers. 2) Elimination of wastes aids in freeing up resources for deployment elsewhere in the business. It implies that lean thinking contributes a growth strategy (Srinivasan, 2004).

Usually companies focus on the issues within the company, e.g. how to reduce inventory to save on carrying costs. Lean thinking would help companies to be more responsive and reliable to customer demands. In turn, customers would choose rather these companies than others that they had poor experience. It will strengthen the relationships with suppliers enabling to build customized products without having a large volume of inventory in-house (Srinivasan, 2004).

To promote flow of products, lean thinking uses some important tools such as 5S system, flow charts, takt time, one-piece flow, cellular layout, standard work, pull replenishment, continuous improvement for the pursuit of perfection, *etc.* We provide descriptions of some of the tools.

5S System.

It improves safety, work efficiency, and productivity and gives employees a sense of ownership. Any organization, which aims to eliminate wasteful activities, should start with the 5S systems principles. To succeed in the lean journey, the organization has to put in practice all of the principles (Srinivasan, 2004). The 5S system consists of five activities, see Figure 2-2.

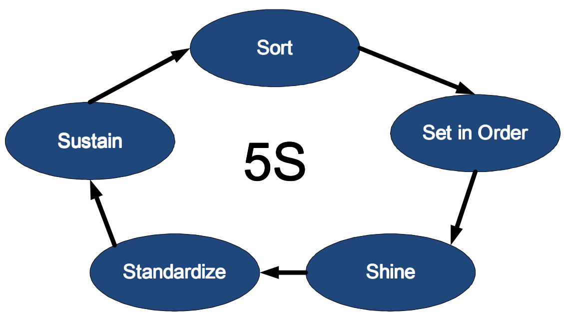


Figure 2- 2 The 5S System (source: Tapping & Shuker, 2003)

1. Sort - involves sorting and removing the unnecessary items (Tapping & Shuker, 2003). It means to organize something that is not organized (Srinivasan, 2004)

2. Set in order – involves arranging necessary items for easy and efficient access (Tapping & Shuker, 2003). The step can completed with the first on (Sort), because there is not big difference between them. The second step creates storage systems and provides visual information about the items stored (Srinivasan, 2004).
3. Shine – involves keeping clean the work area including the maintenance of tools (Tapping & Shuker, 2003). The practical benefit behind the third step is to discover small problems in machinery before big failure occurs (Srinivasan, 2004).
4. Standardize – involves creating guidelines, making standards visual that helps in the working process (Tapping & Shuker, 2003). The step concerns both personal and environmental cleanliness. The employees have to be trained to detect the problems by following the imposed standards to measure and maintain "cleanliness" (Srinivasan, 2004).
5. Sustain – involves education and communication to ensure that everyone follows the 5S standards (Tapping & Shuker, 2003). The last step sustains the first four steps. It is important that top management supports the fifth step by providing incentives that the step becomes as a habit (Srinivasan, 2004).

Flow charts

Flow charts visualize any manufacturing or service process from one step to the next step, *etc*. Through the flow charts it will be able to identify the unnecessary processes and wastes within them. The key to streamline the processes are to eliminate or at least reduce the non-value added activities. The example of the process flow chart, see Appendix 5.

One-Piece Flow

One-Piece flow means that products move one unit at a time between workstations. The goal of one-piece flow is to reduce the lead time of products or to reduce the work in process (WIP) inventory that assimilates during the process. In addition, it helps to improve product quality because the one-piece flow shortens the one-piece feedback loop. To implement the principle of one-piece flow it is desirable that it would be little variability in process times. Moreover, it is important that the process quality and one-piece flow should be linked together (Srinivasan, 2004). In addition, one-piece flow aids in the continuous flow of products (Rother & Shook, 2005).

Cellular layout

Cellular layout means that the workstations are organized in a processing sequence. The cellular layout enhances the one-piece flow. The cellular layout also called a product layout. Common layout configurations used for manufacturing workstations include the U-shaped cell, the T-shaped cell, the L-shaped cell, the C-shaped cell or a serpentine arrangement (Srinivasan, 2004; Tapping & Shuker, 2003). The traditional manufacturing layout is called a process layout where the workstations are grouped by departments or functions (Srinivasan, 2004). The advantages of the cellular layout and one-piece flow are the following:

- WIP reduction;
- Better space utilization;
- Reduction in lead time;
- Productivity improvement in terms of flexibility in allocation tasks to operators and rebalancing production according to urgent orders;
- Quality improvement: immediate feedback on defects;

- Enhanced teamwork and communication;
- Better visibility of all tasks and operations (Srinivasan, 2004, p. 169-170).

Thus, the philosophy of lean thinking involves eliminating waste and unnecessary actions and linking all the steps that create value. In 1996, the initial concept of lean was more extensively defined and described by five key principles (Womack & Jones, 1996), see Figure 2-3.

- Specifying value;
- Identifying the value stream;
- Making value flow;
- Pull scheduling;
- Seek perfection.

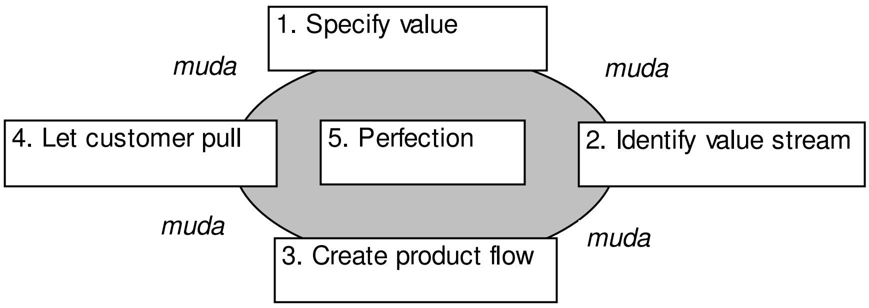


Figure 2- 3 Principles of lean thinking (Source: Womack & Jones, 1996; cited from Harrisson & van Hoek, 2005)

The lean principles will be described in detailed in Chapters 2.3-2.7.

The principles of minimizing waste are applied not even within automobile manufacturing enterprises but also to diverse industries such as furniture, electrical switchgears, aerospace, aircraft maintenance, electrical appliances and office products (Srinivasan, 2004; Harrison & van Hoek, 2005). According to Harrison and van Hoek (2005, p.171) the term "lean thinking refers to the elimination of *muda* (waste) in all aspects of a business", and the approach is totally different from traditional mass production approach.

2.2.1 Application of lean thinking to business processes

As was mentioned before, identifying the wastes in the production processes allows products and information flow through the business processes evenly. It is important to understand the business processes within the whole organizational structure in order to analyze the wastes. Thus, it is important to start the analysis of wastes by identifying the key business processes. The business processes of primer importance are considered such as order to replenishment, order to production, and product development (Harrison & van Hoek, 2005). Tapping and Shuker (2003) named business processes differently. However, they imply the same procedures to be performed. Thus, according to Tapping and Shuker, the business processes are concept to launch, raw material to finished goods and Order-to-Cash processes, see Figure 2-4.

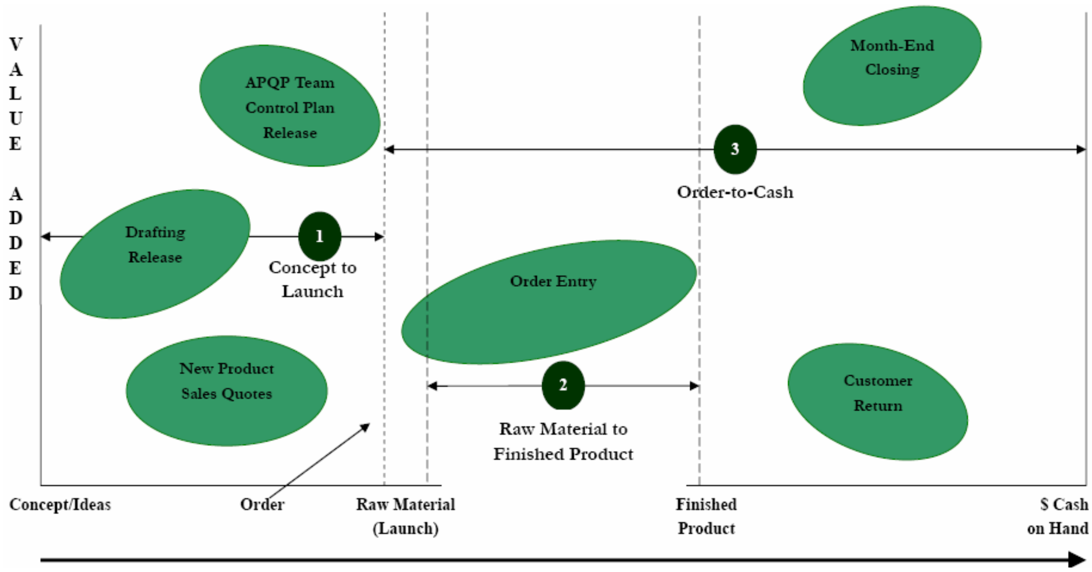


Figure 2- 4 Three areas of the value stream. (Source: Tapping & Shuker, 2003).

Product development or concept to launch

Lean thinking can be applied to the business process is by making the process more effective by supporting the development of products with desirable attributes and features, and achieving this on time. The main processes within the product development/concept to launch process are drafting release process, pricing, procurement, engineering proposals, customer ordering and quotes and control plan process (Tapping & Shuker, 2003; Harrison & van Hoek, 2005).

Order to production or raw material to finished goods

The business process involves all the manufacturing materials and information requirements to deliver the product to the customer with the highest quality, lowest costs and shortest lead time. It can be prosecuted either within the company or can be extended down the supply chain (Tapping & Shuker, 2003; Harrison & van Hoek, 2005).

Order to replenishment or Order-to-Cash

The process begins with the incoming customer order. It can overlap with the raw material-to-finished product value stream. The examples of Order-to-Replenishment/Order-to-Cash value stream are: order lead time process, customer service returned material reports, month-end closing, product enhancement process, *etc.*

Thus, the lean thinking manages the business process by fast lead times. The approaches of vendor-managed inventory and quick response can be very helpful in achieving short lead times of order to replenishment business process. However, the approaches have some limitations, especially when an organization dealing with seasonal products, or does not want to share information, or lacking standard procedures, *etc.* (Tapping & Shuker, 2003; Harrison & van Hoek, 2005).

Each of these business processes involve lean thinking by examination the process, determining waste within it, identifying the causes of the waste, and developing and implementing solutions. The purpose of lean management is not to make someone *work faster,* but rather to streamline the flow that the work *moves faster* through the value stream. (Tapping & Shuker, 2003; Harrison & van Hoek, 2005).

To summarize, lean thinking is about how to eliminate *muda* (waste) from the non-value added activities both within organization and across the supply chain. Eliminating *muda* means enhancing the competitive advantage in terms of reducing lead times and freeing up resources for deployment elsewhere in the business. It implies to be more flexible and responsible to the downstream customers, to have close collaborations with suppliers, and no need to keep high volumes of inventory in-house in order to be able to create a customized product. Lean thinking has close connections with the theories such as the theory of constraints, system dynamics, simulation, and mathematical and expert system-based approaches. There are important tools that can promote the lean flow of products: 5S system, flow charts, *takt* time, one-piece flow, cellular layout, standard work, pull replenishment, continuous improvement and the pursuit of perfection, *etc.* 5S System, flow charts, cellular layout and one-piece flow were described in more detail. There are three business process areas where lean thinking is applicable: concept to launch, raw material to finished goods and Order-to-Cash.

2.3 Lean principle - Specify Value

The first principle, *specify value*, means to define value from the end-customer perspective. It means that value is added along the supply network as raw material is converted into finished product bought by the end customer. For example, the aluminum ore is converted into one of the constituents of a can of cola (Harrison & van Hoek, 2005).

Many dictionaries provide definition for the word "value". The term value tends to have different meaning to almost every individual or organization. The reason of the differentiation of the value term due to the fact that the term is also used in different fields such as mathematics, ethics, music, physic and chemistry (Rutner & Langley, 2000). Table 2-1 provides some definitions of value that can be relevant to use in business field.

Table 2- 1 The definitions of value

	Definition	***References***
Supply Chain Management	A property of a product or service that the customer cares about and would be willing to pay for.	Whicker, Bernon, Templar & Mena, 2006, p.2
Logistics	Providing the right product at the right price, time and place, without error, with consistency over time.	Rutner & Langley, 2000, p. 77
Marketing	Value refers to the perceived worth in monetary terms of the economic, technical, service, and social benefits received by a customer firm in exchange for the price paid for a product offering. Judgments about value also take into consideration alternative suppliers' offerings and prices.	Anderson & Narus, 2001, p.98

Table 2-1 *Continued*

Marketing	A trade-off between benefits and sacrifices perceived by the customer in a supplier's offering.	Ulaga & Chacour, 2001, p. 527.
Marketing & Management	Customer value is typically a dynamic concept because the perceived value of a product or service may change over time. The drivers that motivate a customer's initial purchase may differ from the criteria that connote value during use right after purchase, which in turn may differ from the determinants of value during long-term use	Woodruff 1997; Day & Wensley 1988; Flint, Woodruff & Gardial 1997; cited in van der Haar, Kemp & Omta, 2001, p. 628
Lean thinking	Value is the mean of materials, parts or products that flowing through in the value stream	Koskela, 2004, p. 29

It is argued that value is added to products or services only when the three criteria are fulfilled: customer cares about the change; physically change the item; and a company is doing right at first time (Blackburn, 1991; Gregory & Rawling, 1997: cited in Whicker et al., 2006).

Koskela (2004) provides the inferred meaning of value in parallel with five lean principles that were introduced in Chapter 2.2, see Table 2-2.

Table 2- 2 Many meanings of value within the lean framework (Source: adopted from Koskela, 2004)

Lean principles	Inferred meaning of value
1. Precisely specify value by specific product	1. Specify value = specify product
2. Identify value stream for each product	2. Value stream = material and information flow
3. Make sure flow without interruptions	3. Value = flow of materials without interruptions
4. Let the customer pull value from the producer.	4. Value = product
5. Pursue perfection	5. Value = product

The first principle is to specify value in term of product or product functions. The inferred meaning of value points to specify value. However, the value cannot be seen as itself, because it is attached with the product. Thus, value here is used to mean materials or products (Koskela, 2004).

The second principle means designing the production system including product development, order fulfilment process with goal to avoid the wasteful activities. Thus, the inferred meaning of value stream is the material and information flow including the key partners in the supply chain (Koskela, 2004).

The third principle highlights to make a flow without interruptions. It means to make a flow by eliminating the identified wasteful activities. In the inferred meaning of the principle, the value is the flow. To achieve the waste free flow helps one-piece flow rather than producing in batches (Koskela, 2004).

The fourth principle accentuates that customers pull the products instead of producer pushes the unwanted products. The inferred value of the principle is that the products will be produced in 'just in time' manner that keep lead time under control (Koskela, 2004).

The fifth principle stresses that there is a need for "continuous minimization of waste and maximization of value", associated with JIT and TQC (Total Quality Control) concepts (Koskela, 2004, p. 31). Thus, the continuous improvement should be performed in any lean organization.

As a summary, the concept of value has different meanings depending on the industry where it is used. The value in terms of lean thinking is based on five lean principles. However, the common perception of value is when customer cares about the product, buys it continuously and a company is doing right at first time.

2.4 Lean principle - Identify the Value Stream

The second principle is to *identify the value stream* means to define the whole sequence of processes along the supply network. The mapping of the value stream is very helpful to identifying and removing the sources and causes in the supply network (Harrison & van Hoek, 2005). Womack and Jones (1996, p. 19) defined the value stream as "the set of all the specific actions required to bring a specific product through the three critical management tasks of any business":

- All activities, even non-value added activities, involve in creating products from concept through detailed design and engineering to what a customer is willing to pay for;
- Sharing information along the supply chain based on orders and orders forecasts from the stage of order taking to the stage of delivery scheduling;
- The network of processes and operations from raw materials to a finished product (Womack & Jones, 1996; Tapping & Shuker, 2003).

Mainly, there are three value stream areas for each product family. The areas include multiple processes and activities that usually overlap with other areas. The areas are such as 1) concept-to-launch, 2) raw material-to-finished products, and 3) order-to-cash, see Figure 2-4. (Tapping & Shuker, 2003).

There are many value streams in any organization that involve both the value added and non-value added actions to bring a product from the concept through development, manufacturing to the end customer. In manufacturing, the products are classified in product families. A product family refers to group of parts that share a common processing sequence (Tapping & Shuker, 2003).

It is difficult to choose a value stream to map due to its complexity. Tapping and Shuker (2003) suggest breaking value stream areas into smaller streams. Womack and Jones (2005) suggest mapping only those value streams that a company wants to improve. Tapping and Shuker (2003) propose drawing the maps by starting from the end customer and going towards upstream, including all manufacturing activities that needed to bring product from the concept to the receipt of the customer.

2.5 Lean principle - Make Value Flow

The third lean principle, *make value flow,* means applying the key factors along the supply chain. To minimize delays, inventories, defects and downtime in order to support the value flow are the key factors of the principle. It is important to visualize and simplify the processes to identify and remove waste of value flow. Thus, the above mentioned factors will be achieved (Harrison & van Hoek, 2005).

In order to make value flow the three steps have to be performed. First of all, a company has to focus on the actual object, i.e. specific product, specific order, *etc.* and map that (Womack & Jones, 1996). However, it is important to map only that flow which the company needs to improve (Rother & Shook, 2005). The best results will be achieved if the company will be able to map the value stream from the beginning to the finished product, i.e. including suppliers and n-tiers sub-suppliers. Secondly, it is recommended to ignore the traditional boundaries of jobs, careers and functions organized into departments. The second step makes the first step possible. It will be feasible to remove the barriers across a supply chain by mapping the specific product or product family. It enables the continuous flow of the mapped product. Third, it is important to reconsider specific work practices and tools to get rid of all sorts return flow, scrap, and stoppages allowing the product to flow through the business processes continuously. All these steps have to taken together (Womack & Jones, 1996).

The dedicated cross-skilled team should be created to conduct the work according the mentioned steps. The cross-skilled team should consist of marketing, engineering, purchasing and production professionals including employees of key components and material suppliers firms. Sales and production scheduling are major members of the team in the lean enterprise. Sales department plans the sales campaign according to the capabilities of production system. Thus, it is important that the salesmen would offer according to the production system capabilities to make a smooth flow from sale to delivery (Womack & Jones, 1996).

There are some tools that aid to implement the approach. One of them is "takt time, which synchronizes the rate of production to the rate of sales to customers" (Womack & Jones, 1996 p. 55). The takt time indicates how fast the workshop has to produce a component that is based on the selling takt time, which would correspondent to customers needs. The takt time is calculated by dividing the customer need per day to the available working hours per day. It is simple to produce according the takt time, however, it requires concentrated efforts because the operators have to react quickly in case of some problem arises and will be able to eliminate the reasons from the non-planned stoppage of production (Rother & Shook, 2005). Next tool is the JIT system, which could diminish the role of MRP system. However, if the changeover times of machinery is long and machines are producing in large batches then the inventory will accumulates and the JIT system will be helpless. There is a need to organize a workshop in a way that it contributes the continuous flow. Thus, the flow has to be organized according to production areas by product family including every fabrication and assembly step. The reorganizing a layout of workshop according to product families enables the one-piece flow (see Chapter 2.2), which in turn, enables the continuous flow of the product. To maintain the continuous flow it is important that every machine and every worker will be capable to perform an operation. It implies that there is a need of cross-skilled workers in a workshop that they could switch to other tasks when it is needed or when someone is absent. It also implies that the work has to be standardized by the work team. Moreover, it is important that operators would be able to monitor their own work through mistake-proofing technique. In addition, to enable the continuous flow there is a need to reduce changeover times and batch sizes to the minimum that machinery allows (Womack & Jones, 1996).

2.5.1 Value Stream Mapping

According to Seth and Gupta (2005), Value Stream Mapping (VSM) is the process of mapping the material and information flows for components and sub-assemblies in a value chain from raw material to the customer. Womack and Jones (1996) define VSM as a tool, which allows identify ways to get material and information to flow without interruption, improve productivity and competitiveness, and help people implement system rather than isolated process improvements (cited in Emiliani & Stek, 2004). Womack & Jones (1996), and Rother & Shook (1999) described value-stream maps as "material and information flow maps", which are one-page diagrams showing the processes used to make a product (cited in Emiliani & Stek, 2004). VSM is used to identify the sources of waste in the value stream as basis for implementation plan that helps to see and focus on flow with a vision of and ideal (CMTC, 2003).

VSM is a mapping paradigm used to describe the configuration of value streams and it maps not only material flows but also information flows that signal and control these material flows (Rother & Shook 1999). Seth and Gupta (2005) state that it is necessary to map the value stream of products both within a company and across the supply chain. VSM modeling language includes standard icons, and it is easy to use with its widening dissemination within the manufacturing community, and VSM also includes a step by step approach to transform a current manufacturing state into a Lean Future State, which is the basis of its success in practice (Dinesh & Vaibhav, 2005). VSM tools were popularized by Rother and Shook (1999).

VSM became a popular implementation method for Lean manufacturing, and it is considered as a classification scheme. VSM with seven mapping tools (namely, process activity mapping, supply-chain response matrix, production variety funnel, quality filter mapping, demand amplification mapping, decision point analysis and physical structure mapping) and their major application areas are very useful (Hines & Rich, 1997).

Mostly, the value-stream maps were applied to manufacturing activities, but nowadays the technique is used to map any service business process, including business-to-business sales, retail sales, e-business, auditing, healthcare, education, and government services (Emiliani & Stek, 2004).

Selection of a product family

Before starting the value stream mapping, a particular product or product family should be defined as the target for future improvement. Not all the product can be selected to map the flow that passes through the factory. The mapping of value stream means walking along the processes and drawing all the steps in the process required for a product family. Thus the drawing includes all of the steps including the physical and information flow from door to door in a factory (Rother & Shook, 2005).

To select a product or product family is recommended which passes along the same processes and machinery in the workshop. However, it is recommended to avoid those product or product families which are produced in large batches and are the part of many other product families (Rother & Shook, 2005).

Current state map (CSM)

"The current (or 'as is") status is mapped to capture a snapshot of how things are done and where the improvement potentials lie" (Seth & Gupta, 2005 p.45).

After selecting a particular product or product family, the next step is to draw a CSM, to understand how a workshop currently operates. Moreover, CSM helps in designing a lean flow of FSM. Mapping the process will give operators a clear picture of the wastes that hinder flow. It also enables to reduce or eliminate the identified wastes (Tapping & Shuker, 2003).

In order to observe and understand the value stream from customer perspective, it is suggested to start from the closest point to the customer and work the way upstream through the various processes. When it comes to the drawing of current state map, it should be conducted by the common CSM procedure. According to Tapping and Shuker (2003) the steps of the procedure are the following, and see Figure 2-5:

(1) To begin with, draw the external (or internal) customer and supplier and list their requirements per month, e.g. in items, pieces, *etc.*

(2) Next step is to draw the basic processes in the sequencing order in the value stream by listing the process attributes, i.e. Cycle time, changeover time, quantity of operators, available working time, *etc.*

(3) Then, to draw queue times between processes, e.g. how many days or hours components wait until the next process.

(4) The following step is to draw all communications that occur within the value stream, i.e. information flow.

(5) And finally, to draw push or pull icons to identify the type of workflow, i.e. physical flow.

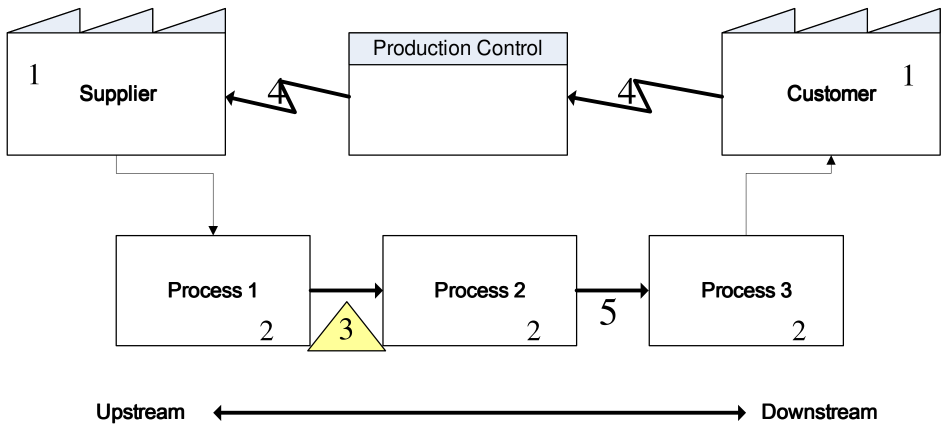


Figure 2- 5 Mapping procedure of CSM (source: Tapping & Shuker, 2003)

Enablers of moving from CSM to FSM

Creating the detailed FSM is a complex and multi-step process where representatives from all the involved companies should form a well coordinated team. According to Brunt (2000), the following enablers are required to make possible transition from CSM to FSM:

(1) A cross-functional team is required to carry out the mapping process. The team has to understand the mapping language and icons and will be able to explain the overview of mapping process.

(2) The business performance benefits achieved in the FSM have to be agreed by all participants firms.

(3) The finance and measurement systems have to be balanced across a supply chain to avoid the conflicts, e.g. conflicts in operational measures in companies within a supply chain.

(4) The assessment of other value streams has to be considered to understand the where these value streams overlap can be created. It is important to take into consideration because in any supply chain occur bottlenecks or capacity constraints.

(5) It is important to consider and analyze the whole value stream: from the customer to supply. Then it would be possible to rethink the delivery of value by removing more waste that incurs cost (Brunt, 2000).

Future state map (FSM)

"Future or "to be' state map shows how things should to be done considering takt time requirements" (Seth & Gupta, 2005 p.45).

After the drawing of CSM next step is to draw FSM. The FSM depicts how the value stream of a product family should look like after eliminating or reducing all the inefficiencies. The proposed future changes and suggestions for the improvement of the value stream are based upon FSM including the different lean tools. The examples of lean tools are FIFO lanes, work-area re-design, supermarkets, kanban, 5S, *etc*. These tools help to meet customer requirements, establish a continuous workflow and distribute work evenly. Moreover, FSM visualize where these tools are to be used (Tapping & Shuker, 2003).

The process for mapping the future state takes place in three phases, which has to be performed together:

(1) Customer demand phase: understanding of customer demand for services and work units, including quality characteristics and lead time.

(2) Continuous flow phase: implementation of continuous flow. The indicator here is that customers receive the right work unit, at the right time, in the right quality.

(3) Leveling phase: distribution of work evenly (e.g. by volume and variety) to reduce queue times (Tapping & Shuker, 2003).

2.5.2 The three types of activity

Manufacturing, especially lean manufacturing strives to reduce waste in human effort, inventory and time to market. Manufacturing space is becoming highly responsive to customer demand, same as the demand to produce the quality products is focused on the efficient and economical manner (Seth & Gupta, 2005). Since lean thinking analyzes business processes systematically by identifying and removing wastes, it helps also to distinguish between value added and non-value added processes (Harrison & van Hoek, 2005). Classification of processes is based on the elimination of waste (Seth & Gupta, 2005). There are two types of activities classification, see Table 2-3.

Table 2- 3 Classification of activities

Activities, classified by Monden (1993); cited in Hines & Rich, 1997	Activities, classified by Womack & Jones (1996)
Value-added activities	Value-added activities
Necessary but non-value added activities	Type One *muda*
Non-value added activities	Type Two *muda*

Value-added activities involve the conversion or processing of raw materials or semi-finished products through the use of manual labor. Examples include activities such as sub-assembling of parts, forging raw materials, and painting bodywork (Monden, 1993; cited in Hines & Rich, 1997). Thus, value added activities are the machinery working time required to produce a product.

Meanwhile, necessary but *non-value added activities* or Type One *muda* may be wasteful but are necessary under the current operating procedures. Examples include such as walking long distances to pick up parts, unpacking deliveries, and transferring a tool from one hand to another. In order to eliminate these types of operation it would be necessary to make major changes to the operating system such as creating a new layout or arranging for suppliers to deliver unpacked goods. Such change may not be possible immediately (Monden, 1993; cited in Hines & Rich, 1997).

Non-value added activities or Type two *muda* stands for the pure waste and involves unnecessary actions, which can be eliminated completely. Examples include waiting time, stacking intermediate products, double handling and *etc* (Monden, 1993, cited in Hines & Rich, 1997). Typically, 95% of all lead time is non-value added activities (CMTC, 2003).

2.5.3 Wastes

According to Hines, Rich, Bicheno, Brunt, Taylor, Butterworth & Sullivan, (1998), understanding wastes within the supply chain is considered as the first stages of VSM. Researchers and practitioners try to identify waste in value streams and, hence, find an appropriate route to removal, or at least diminishing the influence of waste (Hines & Rich, 1997).

Waste takes many forms and can be found at any time and in any place. It may be found hidden in policies, procedures, production process, product designs, and in other operations (Seth & Gupta, 2005). Waste consumes resources but does not add any value to the product (Womack & Jones, 1996). Russell and Taylor (1999) define waste as anything other than the minimum amount of equipment, effort, materials, parts, space and time that are essential to add value to the product (cited in Seth & Gupta, 2005).

To identify and remove wastes to able to drive competitive advantage was pioneered by TPS. However, the focus was more on productivity that on quality (cited in Hines & Rich, 1997). According to Bicheno (1991), the reason for focusing on productivity is that improved productivity leads to leaner operations, which help to uncover further waste and quality problems in the system. Therefore, the systematic attack on waste is also a systematic attack on the factors underlying poor quality and fundamental management problems (cited in Hines & Rich, 1997).

According to Shingeo (1989), Bicheno (1994) and Taiichi (1985) there are seven types of wastes, which are accepted commonly in manufacturing industry (cited in Hines & Rich, 1997): 1) overproduction, 2) waiting, 3) transportation, 4) inappropriate processing, 5) unnecessary inventory, 6) unnecessary movement and 7) defects.

The waste of overproduction

The waste of overproduction is considered as the most serious waste as it discourages a smooth flow of goods or services and is likely to inhibit quality and productivity. Such overproduction also tends to lead to excessive lead and storage times. As a result defects may not be detected early, products may deteriorate and artificial pressures on work rate may be generated. In addition, overproduction leads to excessive work-in-progress stocks, which result in the physical dislocation of operations with consequent poorer communication. This state of affairs is often encouraged by bonus systems that encourage the push of unwanted goods. The pull or kanban system was employed by Toyota as a way of overcoming this problem (Hines & Rich, 1997).

The waste of waiting

The waste of waiting occurs when time is not being used effectively. In a factory, the waste occur whenever products are not moving or being worked on. The waste affects both products and workers, each spending time waiting. The ideal state should be no waiting time with a consequent faster flow of goods. Waiting time for workers may be used for training, maintenance or kaizen (continuous improvement) activities and should not result in overproduction (Hines & Rich, 1997).

The waste of transportation

The waste involves goods being moved from one process to the next and adds no value to the products. Taken to an extreme, any movement in the factory could be viewed as waste, and thus, minimization of transportation is usually sought. In addition, double handling and excessive movements are likely to cause damage and deterioration with the distance of communication between processes proportional to the time it takes to feed back reports of poor quality and to take corrective action (Hines & Rich, 1997).

The waste of inappropriate processing

The waste of inappropriate processing occurs in situations where overly complex solutions are found to simple procedures such as using a large inflexible machine instead of several small flexible ones. The over-complexity generally discourages ownership and encourages the employees to overproduce to recover the large investment in the complex machines. Such an approach encourages poor layout, leading to excessive transport and poor communication. The ideal, therefore, is to have the smallest possible machine, capable of producing the required quality, located next to preceding and subsequent operations. Inappropriate processing occurs also when machines are used without sufficient safeguards, such as poke-yoke (mistake-proofing technique) or jidoka (stopping a manual line or process when something goes wrong) devices, so that poor quality goods can be made (Hines & Rich, 1997).

The waste of unnecessary inventory

The waste of unnecessary inventory is a sign that flow was disrupted, and that there are problems in the process (Harrison & van Hoek, 2005). Unnecessary inventory tends to increase lead time, preventing rapid identification of problems and increasing space, thereby discouraging communication. Thus, problems are hidden by inventory. To correct these problems, they first have to be found. This can be achieved only by reducing inventory. In addition, unnecessary inventories create significant storage costs and, hence, lower the competitiveness of the organization or value stream wherein they exist (Hines & Rich, 1997).

The waste of unnecessary movements

The waste of unnecessary movements involves the ergonomics of production where operators have to stretch, bend and pick up when these actions could be avoided. Other examples are such as walking between processes, taking a stores requisition for signature or emptying parts from one container into another (Harrison & van Hoek, 2005). Such waste is tiring for the employees and is likely to lead to poor productivity and, often, to quality problems (Hines & Rich, 1997).

The waste of defects

The waste of defects implies that producing defects costs time and money (Harrison & van Hoek, 2005). Thus, the bottom-line of waste are direct costs. The Toyota philosophy tells that defects should be regarded as opportunities to improve rather than something to be traded off against what is ultimately poor management. Thus defects are seized on for immediate kaizen activity (continuous improvement concept) (Hines & Rich, 1997).

The seven wastes that are listed above were tested empirically for two years. It was shown that it was easy to identify waste and propose ways to reduce or eliminate it. However, it was found that there were actually more than seven wastes in the real life of organizations (Hines, et al., 1998). Furthermore, the seven wastes "lacked an ability to take on a more exact costing of existing wastes and hence the potential for improvement, and they did not easily represent the human interaction stages of the value stream" (Hines et al., 1998 p.33). Five more wastes were added to cover the lacked functions. They are the following: 1) Power and Energy, 2) Human Potential, 3) Environmental Pollution, 4) Unnecessary Overhead (including training), and 5) Inappropriate Design (Hines et al. 1998).

2.5.4 Additional Value Stream Mapping tools

Harrisson and van Hoek (2005) state that by mapping processes along the supply chain, it is possible to classify the value added and non-value added activities in the performed activities such as transportation, storage, inspection or delay. Moreover, Hines and Rich (1997) argue that supply chain mapping tools help to provide visibility along the value stream and companies can choose improvement activities to achieve the maximum benefit.

Big picture mapping means a visual approach designed to display at a high level a major part or whole organization. Mapping the big picture of value stream captures the overall value stream including information and physical flow. However, gaps exits in the big picture mapping, and further detailed value stream mapping work is required to fill in the gaps left by big picture mapping (Hines & Taylor, 2000).

There are seven mostly used mapping tools: 1) Process Activity Mapping, 2) Supply Chain Response Matrix, 3) Production Variety Funnel, 4) Quality Filter Mapping, 5) Demand Amplification Mapping, 6) Value Analysis Time Profile, and 7) Decision Point Analysis (Hines & Taylor, 2000). The summary of the seven mapping tools are provided in Table 2-4.

Table 2- 4 Summary of seven value stream mapping tools (condensate from: Hines & Taylor, 2000; Sullivan et al., 2002; Hines & Rich, 1997; Krishnamurthy & Yauch, 2007)

VSM tools	Overall identification	Usage	Orientation/Objective/ Advantage
Process Activity Mapping	Detailed mapping of the order fulfillment process	To identify lead time and productivity opportunities for both physical product flows and information flows of the entire supply chain	To map out every step of activity that occurs throughout the order fulfillment process.
Supply chain Response Matrix	Evaluation of inventory and lead times	To identify large sectors of time and inventory; To allow assessing the need to hold stocks within the short lead-time replenishments.	To improve, or maintain the service level of the entire chain with fewer costs.
Production Variety Funnel	Shows the number of product variants at each stage of the manufacturing process	To identify inventory by combining the flexibility of the plant with short lead time. Useful in determining opportunities for postponement; Useful to highlight bottleneck areas of design.	To gain a better understanding of how a supply chain operates and how to manage the complexities in the supply chain; To identify where buffer stocks may be held prior to customization; To specify target inventory reductions, and where to make changes in the processing of products; To see the holistic view of the company or supply chain.

Table 2-4 *Continued*

Quality Filter Mapping	Identifying the quality problems in the order fulfillment process or in supply chain	To show where three different types of quality defects occur (Product defects, Scrap defects, and Service defects) by integrating quality and logistics performance measures	To establish both internal and external quality levels as well as levels of customer service.
Demand Amplification Mapping	The demand amplification map is a graph of quantity against time	Known as 'bullwhip effect' or 'Forrester effect'; To examine scheduling and batch sizing policies and inventory decisions.	Shows why inventory exists and highlights the existing problems of inventory and batch size; To analyze inventory decision making for further analysis; To redesign the configuration of value stream if it necessary.
Value Adding Time Profile	Mapping activities considering in Cost-Time Profiles	To show accumulation of both value adding and non value adding costs against time	To understand where waste is added. To pinpoint where major improvement efforts might effectively be focused. To show where time may be reduced for various activities charted on the horizontal axis.
Decision Point Analysis	Shows where in a supply chain exist an expected level of buffer stock	To determine where the products' flow in the value stream goes from push system to pull system.	To access both downstream and upstream processes. To analyze where excess of inventory exist in value stream. To align the processes along the supply chain by relevant pull or push philosophy. By moving the decision point along the supply chain it allows for a better design of the value stream.

To summarize Chapter 2.5, making value flow it is necessary to select a product family to be able to draw CSM. To make it possible moving from CSM to FSM the cross-functional team is required. Furthermore, it has to be agreed upon the business performance benefits, the finance and measurement systems have to be balanced, the assessment of other value streams has to be considered. In order to remove wastes it is important to analyze the whole value stream. There exist some tools helping to implement this approach: *takt* time, JIT, layout reorganization, one-piece flow, cross-skilled workers, standardized work, reduction of changeover times and small batch sizes. Through mapping the current state of value stream it is possible to identify wastes. The most common wastes are such as overproduction, waiting, transportation, inappropriate processing, unnecessary inventory, unnecessary movement, and defects. In addition, there exist detailed value stream mapping tools for "gap filling" in the CSM, that were shortly reviewed.

2.6 Lean principle - Pull scheduling

The forth lean principle is *pull scheduling* means producing products only in response to a signal from the customer that it needs more products. This implies that demand information of customers' orders has to be available across the supply chain. If it is possible, a company should deliver products from manufacturing facilities, not from stock, and use customer orders prior to forecasts (Harrison & van Hoek, 2005).

There exist two types of production control systems: "Pull" and "Push" systems. In the pull the system the products are "pulled through the chain in response to demand from the end-customer. This contrasts with a push system, where products are made … in response to central plan or schedule" (Harrison & van Hoek, 2005, p. 157). Push systems are widely used for Materials Requirements Planning (MRP) and for Manufacturing Resources Planning (MRP II) systems. Thus, the push system is totally based on planning and forecasting. The pull system does not schedule the start of work, instead authorizes production (Coyle et al., 2003). Thus, the pull system is based on customer orders.

According to Womack and Jones (1996, p.67), "*Pull* means that no one upstream should produce a good or service until the customer downstream asks for it". It means that the manufacturing starts at the moment when a customer places an order. The manufacturing works through all the required production processes to bring the product to the customer.

To enable lean production for the pull system, TPS used a technique of *level scheduling,* and *kanban* (Womack & Jones, 1996). Level scheduling means evenly work distribution required to fulfill customer demand over a periond of time, i.e. week, day or hour (Tapping & Shuker, 2003). "Kanban is a form of visual control, using cards to trigger action and reorder" (Tapping & Shuker, 2003 p.103). Thus, the above mentioned technique carries and controls the detailed information about the production for each single process until the order is implemented (Womack & Jones, 1996). The production principle of the pull system is "don't make anything until it is needed; then make it very quickly" (Womack & Jones, 1996 p. 71). The advantage is that company will be more responsive to customer demand due to quick changeover time, improved quality and ability to make products at short notice. The benefit will be reduction of lead time and massive inventories (Womack & Jones, 1996).

Next, to enable the lean distribution for pull system, a broad network of suppliers is required. Since suppliers offer a wide variety of parts, a manufacturing company gains in the reduction of raw material storage by shrinking the size of the storage bins, and reducing the lot size for orders. Moreover, instead of ordering from suppliers on a weekly or monthly basis, a daily order or just the required amount is desired. As the result, the reduction of inventory, the saving space in warehouse, and faster lead time is gained (Womack & Jones, 1996).

As a summary on the pull scheduling benefit, we quote "get rid of lead times and inventory so that demand is instantly reflected in new supply rather than the current situation of misjudged supply perennially searching for demand and creating chaos in the process"

(Womack & Jones, 1996 p.88). Level scheduling and kanban control system enables the pull approach.

2.7 Lean principle - Seek Perfection

Four lean principles (described above) are used to perform the fifth principle, *seek perfection*. It can be performed by getting better at everything, i.e. eliminating waste at every step (Harrison & van Hoek, 2005). According to Womack and Jones (1996) "there is no end to the process of reducing effort, cost, and mistakes while offering a product which is ever more nearly what the customer actually wants" (cited in Koskela, 2004). In other words, there is continuous approach of waste minimization and value maximization by maintaining and improving the working standards through small, gradual improvements. Continuous improvement is associated with JIT and TQC (Total Quality Control) systems (Koskela, 2004).

There are two paths enable to pursue perfection: Incremental improvement and Radical improvement (Womack & Jones, 1996; Tushman & O'Reilly, 1996). In lean terminology *kaizen* stands for the incremental improvement and *kaikaku* stands for the radical improvement.

To perform both types of improvement the management of a company first, needs to apply the four lean principles that were described before, to form the view of the "perfection". Second, the management has to decide what type of *muda* to hit first. The combination of both changes a company will be able to increase productivity, decrease inventories, errors, and lead times (Womack & Jones, 1996).

However, without transparency any improvements are possible. A lean enterprise has to be transparent with its suppliers, sub-contractors, sub-suppliers, distributors, customers and employees to be able to see the processes and discover better ways to serve customers (Womack & Jones, 1996).

To sum up, the fifth lean principle, seek perfection, means the continuous improvement approach by performing the incremental (*kaizen*) and radical (*kaikadu*) changes and enabling the transparency across a supply chain.

2.8 Postponement

The concept of postponement has a long history of practical applications, as well as academic literature. In 20's the concept was applied practically whereas the empirical implication appeared in the 1960´s. The logic behind postponement is that the manufacturing and logistics activities can be postponed until the customer places an order (Pagh & Cooper, 1998). This means to postpone changes in inventory location downstream in the supply chain to the latest possible point (Bucklin, 1965). Thus, the risk and uncertainty both in production and logistics activities can be reduced or fully eliminated (Pagh & Cooper, 1998). The other side of postponement is speculation, which states that inventories in a supply chain should be found "at the earliest possible time to reduce the cost of supply chain" (Pagh & Cooper, 1998 p.14). Speculation is based on the forecasting. It implies that if a company bases the production less on forecasting, the postponement of inventory will be moved upstream. It will be possible "to gain economies of scale in manufacturing and logistics operations, and limit the number of stockouts" (Pagh & Cooper, 1998 p.14). The point where the speculation strategy changes into the postponement strategy calls the decoupling point which shows where exists an excess inventory in a supply chain (Olhager, Selldin & Wikner, 2004).

There are four basic postponement strategies introduced by Cooper, Zinn and Browersox (Pagh & Cooper, 1998). The four strategies are presented in Figure 2-6 in combination of manufacturing and logistics postponement, and speculation.

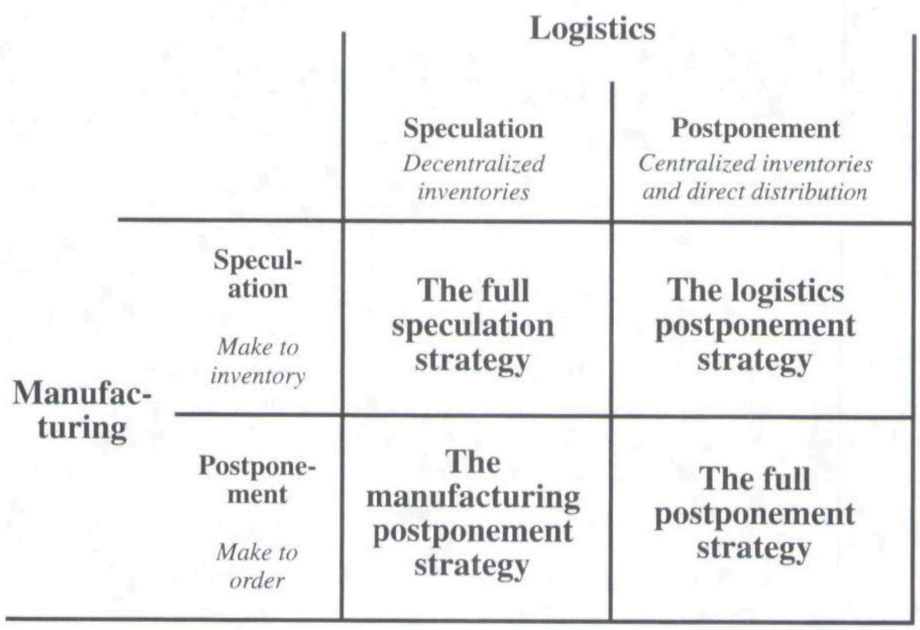


Figure 2- 6 The postponement/speculation strategies (source: Pagh & Cooper, 1998)

Thus, the four strategies are such as the full speculation strategy, the logistics postponement strategy, the manufacturing postponement strategy, and the full postponement strategy.

The full speculation strategy

The strategy is mostly used by companies, which base all manufacturing and logistics operations on forecasts. The decoupling point is positioned at the downstream in the supply chain, close to the end customers. The final-finished products are stocked in warehouse and will be decentralized distributed to customers (Pagh & Cooper, 1998). It is called as 'make-to-stock' product delivery strategy (Olhager, et.al., 2004). The results will be such as low production costs, high inventory costs, low distribution costs and high level of customer service (Pagh & Cooper, 1998).

The manufacturing postponement strategy

The strategy is performed at some point downstream by product differentiation. The final operations are postponed until a customer places an order. The decoupling point will be positioned before the final manufacturing operations. It is called as 'assembly-to-order' product delivery strategy (Olhager, et.al., 2004). For example, Hewlett-Packard decides to postpone the final manufacturing operations of printers at the local distribution centers, where the printers are fully customized after the customer order is placed. The strategy is useful when it is important to have inventories close to customers. The results will be such as medium-to-high production costs, medium-to-high inventory costs, low distribution costs and medium-to-high level of customer service (Pagh & Cooper, 1998).

The logistics postponement strategy

In this strategy manufacturing is based on speculation, i.e. on forecasting, and logistics is based on postponement, i.e. on customer orders. It means that fully finalized products from a plant or central warehouse are shipped to final customer/retailer. Thus, the decoupling point will be moved upstream to the plant or central warehouse level. All manufacturing activities are based on forecasting and products are stored in a warehouse. The logistics activities are based on the customer orders. The results will be such as low production costs, low-to-medium inventory costs, high distribution costs and low-to-medium level of customer service (Pagh & Cooper, 1998).

The full postponement strategy

The manufacturing and logistics operations are based on customer order, thus, the strategy has the highest level of postponement. All the operations such as manufacturing, final assembly and packing are performed at the production plant and products are shipped to directly to retailer/customer. It is also called as engineer-to-order product delivery strategy (Olhager, et.al., 2004). The results will be medium-to-high production costs, low inventory costs, high distribution costs and low level of customer service (Pagh & Cooper, 1998).

In summary, there are four generic postponement strategies that are based on the combination of the manufacturing and logistics postponement and speculation strategies. Speculation strategy is based on forecasting while postponing strategy is based on customer orders. The decoupling point is the point where the speculation strategy is shifted to postponement strategy. In addition, the decoupling point shows where inventory excess exists in a supply chain.

2.9 Positioning an organization in terms of supplier relations

"To understand positioning the organization in terms of supplier relations is to get a better understanding of the nature of the suppler relations in the chain to identify opportunity for collaborative activities" (Scott & Westbrook, 1991 p.26).

The understanding of the nature of the supplier relations influences the scope of supply chain enhancement of any company. There are two key indicators, which determine the positioning of buyer/supplier relations. First is what number of suppliers the customer has, and the second, how close are the relationship with them. The closeness of relationship varies in a scale from "Arm's length" – Regular Sub-contractor – Close Collaboration to Own Company or own subsidiary. The number of supplier varies from few, implying long term relations to many, implying short term relations. Companies that try to gain more control over their supply chain reduce the number of suppliers and engage in long term relations (Scott & Westbrook, 1991).

By reducing the number of supplier, the companies move closer by collaborating with suppliers without vertical integration. Dwyer and Schurr (1987) stated that this involves significant change in supplier relations by managing the change. The relations can be determined by the following five factors:

(1) Extent of dependence on the chain – the proportion of a supplier's business affects the attitude and commitment to collaborative relations;

(2) Longevity of the relationships – long term relations and personal working relations should not be underestimated;

(3) Technological or process links – the technological context is when a supplier creates a relationship with mutual dependence by owning tools, which are needed to make a product. The process context is the ordering through a call-off schedule.

(4) The existence of legal ties and – e.g. contracts, shared patents or other legally binding arrangements;

(5) The length and complexity of the chain – if a supply chain consists of many 3rd tier of suppliers, a company will be less dependent on end user demand (cited in Scott & Westbrook, 1991).

As the most important factor Scott and Westbrook (1991) refers the extent of dependence on the chain. The relationship can be measured by first, "the relative importance of the customer to the supplier's order book and second, the relative importance of those suppliers to the customer's purchased materials" (Scott & Westbrook, 1991 p. 29).

The possible positions of customer/supplier relationship are summarized in Figure 2-7.

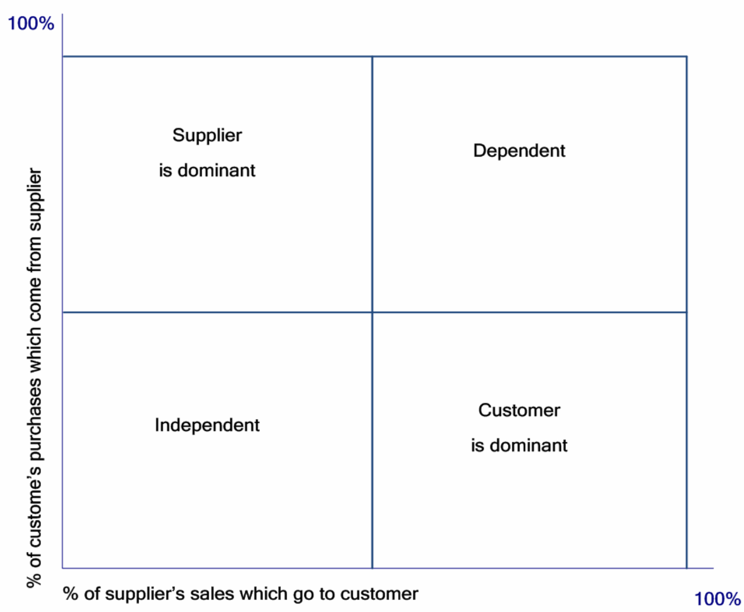


Figure 2- 7 The customer/supplier relation grid (Source: Scott & Westbrook, 1991)

In the customer/buyer dependence grid is shown that supplier's independence and customer dependence were seen as desirable and in the opposite, non-desirable relations were seen when supplier and customer are dominant. Thus, in order to engage in global competition the companies are forced to collaborate (Scott & Westbrook, 1991). Therefore, the attitudes of purchasing should be changed from traditional purchasing attitudes to supply chain approach, as shown in Table 2-5.

Table 2- 5 Traditional purchasing vs a supply chain approach (Source: Scott. & Westbrook, 1991)

Traditional purchasing attitudes	**Supply Chain approach**
Good supplier are ● At arm's length ● Changed frequently ● Giving the lowest quote for a given specification **Independence**	Good suppliers are: ● Trustworthy ● Committed to the longer term ● Innovative ● Committed to quality **Dependence**

The supply chain approach should be taken into consideration of high importance. The companies should adapt the supply chain approach in order to survive and prosper in an intensively competitive world. In order to adapt the supply chain approach, companies have to understand the nature of supplier relations in their supply chains by viewing where they are now and how they can move to closer collaboration. Furthermore, the analysis of the factors affecting relationship between customer and supplier can help companies to determine the nature and the scope of relationships (Scott & Westbrook, 1991).

To sum up, the understanding of the nature of the supplier relations influences the scope of supply chain enhancement of any company. The relationship between buyer/supplier varies from loose to close. Companies enter into close relationships with suppliers in order to compete and to have control over a supply chain. The relationships can be measured by the above mentioned factors in order to determine how dependent the relationships between buyer/supplier are. Through the buyer/supplier dependence grid companies can determine the existing relationships to decide what type of relationship they will engage in future, i.e. traditional or supply chain approach.

2.10 Summary of the theoretical background

Since our study is about mapping the value stream to identify wastes at HAGS, we applied Lean approach as a framework. We started with lean production. Srinivasan (2004), Seth and Gupta (2005) and Gross (2003) provided the information about lean production including history, goals and enablers of lean manufacturing. Björnfot (2006) contributed with the essentials of Lean Manufacturing. Womack, Jones and Roos (1990), and Fleischer and Liker (1997) contributed with the benefits of lean manufacturing.

To understand lean thinking concept we referred to Harrison and van Hoek (2005) and Womack et al. (1990) works. Lean thinking includes the tools described in Tapping and Shuker (2003) and Srinivasan (2004). We based the study on the five lean principles supported originally by Womack and Jones (1996) and cited from Harrisson and van Hoek (2005). Tapping and Shuker (2003) and Harrisson and van Hoek (2005) contributed to the study by determining the three areas of the value stream application.

To describe all the five lean principles we found relevant to base the study mainly on Womack and Jones (1996), and Tapping and Shuker (2003) works. Value description was supported by Whicker, Bernon, Templar and Mena (2006), Rutner and Langley (2000), Ulaga and Chacour (2001), Zeithaml, Parasuraman and Berry (1990) and Koskela (2004). Whicker et al. (2006) summarized the work of Blackburn (1991), and Gregory and Rawling (1997) which introduced the three criteria of how customers measure value. However, we found some limitations of applications of the five lean principles from Koskela (2004).

Value Stream Mapping was popularized by practicians Rother and Shook (2005). Rother and Shook (2005) provided us with Current State Mapping and Future State Mapping methodology. California Manufacturing Technology Consulting (CMTC) (2003) supported with the knowledge of why VSM is used. Emiliani and Stek (2004), and Dinesh and Vaibhav (2005) contributed with application of Value Stream Mapping in other industries. The three types of activities in any business were classified by Monden (1993) and Womack and Jones (1996). We referred to Hines, Rich, Bicheno, Brunt, Taylor, Butterworth and Sullivan (1998) why the identification of waste is useful. Hines and Rich (1997) summarized the study of Shingeo (1989), Bicheno (1994) and Taiichi (1985) about seven types of wastes, which exist in manufacturing industry. We found the additional value stream mapping tools which are the "gap filling" tools for the Current State Map, and are useful to look deeper in the waste related problems identified by CSM. It was supported by Hines and Taylor (2000). The summary of the seven mapping tools about the overall identification, usage, objectives and advantages was condensated from Hines and Taylor (2000), Sullivan, McDonald & Van Aken (2002), and Hines and Rich (1997).

Spearman et al (1990) provided the difference between"pull" and "push" systems that we have described in pull scheduling chapter. Harrisson and van Hoek (2005), Womack and Jones (1996), and Tapping and Shuker (2003) contributed the study by providing the knowledge about the pull scheduling principles. The concept of seek perfection was described with the reference of Womack and Jones (1996), Harrison and van Hoek (2005) and Koskela (2004). Tushman and O'Reilly (1996), Womack and Jones (1996) contributed to the study with explaining the difference between the incremental and radical changes.

Pagh and Cooper (1998) are used to analyze the four postponement and speculation strategies, which were based on the previous works be Cooper, Zinn and Browersox. Bucklin (1965), and Olhager, Selldin and Wikner (2004) were referred in order to determine the decoupling point in the four postponement strategies. Scott and Westbrook (1991) are relevant for analysis of the positioning of a company in terms of relationships with suppliers by the customer/supplier dependence grid.

3 Methodology

The purpose of this chapter is to describe the research approach and methods for achieving the research objective a combination of theoretical and empirical methods is proposed.

A research can be defined as any organized inquiry carried out to provide information for solving problems. Business research is a systematic inquiry whose objective is to provide information to solve managerial problems or management dilemma: the problem or opportunity that requires a management decision (Cooper & Schindler, 2003).

The purpose of a research may be organized into three groups based on what the researcher is trying to accomplish: explore a new topic, describe a phenomenon, or explain why something occurs. Thereby, studies may have multiple purposes, i.e. to explore, describe or explain, but only one is dominant usually (Neuman, 2003).

According to research objective and research questions this study primarily has descriptive and explanative character. According to Robson (2002), the object of descriptive research is to "portray an accurate profile of persons, events or situations" (cited in Saunders, Lewis & Thornhill, 2003). Since our study provided a relatively detailed and accurate picture of the situation with value stream at HAGS we distinguished it as being *descriptive*. Eventually, our study involved significant *explanatory elements* since we analyzed and explained the presence of wastes in the value stream at HAGS and found the links between various wastes.

3.1 Induction vs. Deduction

There are mainly two research approaches such as inductive and deductive that can be applied in a scientific study. The aim of inductive study is to "understand the phenomenon in its own terms" (Hirshman, 1986), i.e. building a theory through data collection (cited in Golicic, Davis & McCarthy, 2005 p.60). On the other hand, the aim of deductive approach is to "add the body of knowledge by building formal theory that explains, predicts and controls the phenomenon of interest" (Golicic, et al., 2005, p.60). Thereby, deductive approach tests theory by "confronting the theory with real-world data" (Golicic, et al., 2005, p.60).

The problem that we stated for our research makes a deductive approach relevant. The reason we chose this approach is that we were able to apply the existing literature and theoretical methods to conclude on the collected empirical data. Furthermore, the authors (Golicic, et al., 2005) stated that the deductive approach dominated in logistics and supply chain phenomena research. We applied already existing lean thinking principles, including the method of value stream mapping, for analyzing the supply chain (Womack & Jones, 1996; Tapping & Shuker 2003; Rother & Shook, 2005). It led us to description of problems in the existing product family value stream at HAGS and explanation of the identified wastes.

3.2 Case study

We chose to conduct a case study as a research strategy. According to Saunders, et.al. (2003), it is important to define a research strategy since it works as a general plan of how we are going to answer our research questions. Robson (2002) characterizes case study as "a strategy for doing research, which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence" (cited in Saunders, et al., 2003, p.93). Yin (2003) argues that the type of research question points to what kind of research strategy to conduct. “How” and ”why” questions are more explanatory and likely to lead to the use of case studies, histories, and experiments as the preferred research strategies (Yin, 2003).

Case studies are preferred prior to histories or experiments when the questions such as “how” and “why” are best suit to ask about “a contemporary set of events, over which the investigator has little or no control” (Yin, 2003, p. 9) and “investigates a contemporary phenomenon within real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Yin, 2003, p. 13). In addition, qualitative case studies are often used to understand the organizational process (Remenyi, Williams, Money & Swartz, 1998).

According to Yin (2003), there are six main sources of evidence to be applied in a case study. The sources of evidence are such as documentation, archival records, interviews, direct observations, participant observations, and physical artifacts.

Furthermore, case studies are of two types mainly: single case studies and multiple case studies. There are two reasons guiding the decision on which type of case study to use:

- What is the reason for the choice of subject, and
- How much external validity is felt to be necessary implying how much the researcher might wish to generalize from a particular case study (Riley, Wood, Clark, Wilkie, & Svivas, 2000).

The rationale for a single case study is to test a well-formulated theory or to deal with an extreme or unique case, or to observe a phenomenon, which was inaccessible for investigation. On the other hand, the data conducted from multiple-cases is considered to be more compelling and the overall study is more robust due to the ability to compare and contrast findings. However, the multiple-cases are resources and time extensive and are not applicable to conduct unique or extreme case (Yin, 2003).

To conduct the study at HAGS we used the single-case study strategy. We investigated the value stream of Origo product components in the real life context using the multiple sources of evidence such as interviews with the management at HAGS and with a supplier and sub-contractor, study of internal documentation, and observations. In addition, we had no control over the phenomenon. The investigated phenomenon was the value stream of Origo components, where wastes were identified.

Next, we addressed the following research questions to achieve the purpose of the study:

RQ1. *How* can the lean thinking framework be applied in searching for wastes in the flow of Origo family components?

RQ2. *What* are the reasons for the wastes in the Origo value stream? (“Why”-type of question)

RQ3. *What* can be done in order to reduce or eliminate the wastes in the flow of Origo family components?

In order to answer the research questions, the following methodology is proposed, as shown in Figure 3-1.

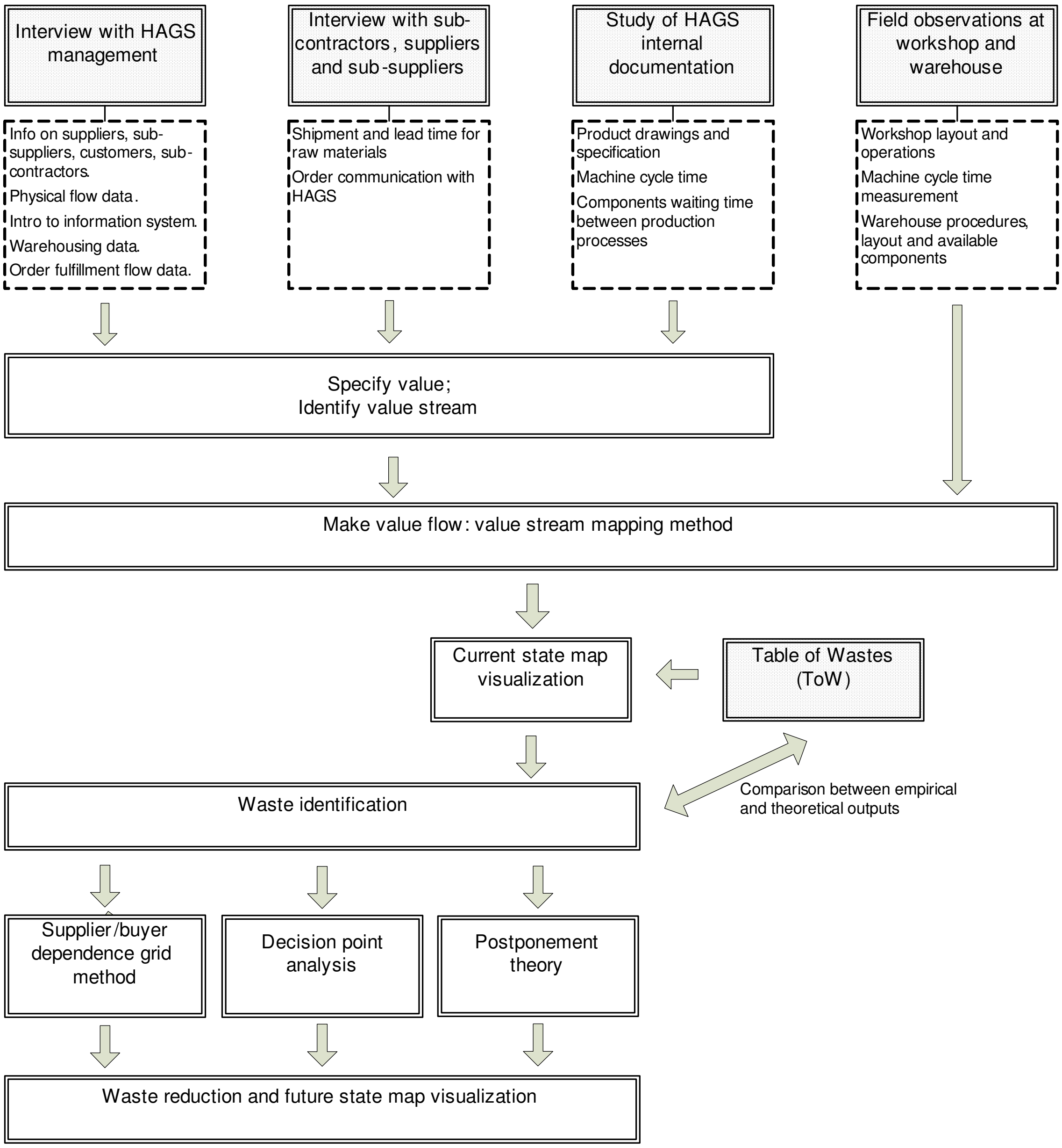


Figure 3- 1Research methodology flowchart

The methodology consists of combination of theoretical and empirical methods, which were applied within the lean thinking framework. The blocks representing the data collection methods are made in dotted pattern. The boxes that are below the data collection blocks show what kind of information was gathered. The interviews and the internal HAGS documentation were used within the lean thinking framework for specifying value and identifying the value stream. The field observations let us look deeper into the value stream of Origo components. Using the gathered information from all above data collection methods as the input for the value stream mapping method, we constructed the current state map (CSM) in order to identify the wastes in the Origo flow. The Table of Waste (ToW) was used as additional empirical tool to construct the CSM and then identify the wastes at the mechanical workshop (see the horizontal arrow directed from the ToW block). The use of ToW was conditioned by limitations of the field observation in the mechanical workshop, where not all the Origo components were available for observation. On the other hand the ToW was applied to confirm the results obtained by the value stream mapping method (see the double-end arrow between the ToW and waste identification blocks). The additional theoretical methods such as decision point analysis, supplier/buyer dependence grid and postponement theory were applied for deeper investigation of the situation at HAGS and the relationships between the key business partners in the value stream of Origo. As the result of the analysis, the solutions to reduce the influence of wastes were proposed and visualized in the draft of the future state map of Origo components, where the main principles of information and physical flow are shown.

3.3 Data collection

Data is the empirical evidence or information that one gathers carefully according to rules or procedures. Every researcher collects data using one or more techniques. The techniques may be grouped into two categories: quantitative and qualitative. According to Saunders, et. al. (2003), the main difference between the two methods is that the quantitative method uses the research instruments, such as diagrams and statistics to gather, analyze and measure information, which is derived from numbers. In contrast, the qualitative method depends more on the skills of a researcher, interviewer or observer, who gathers the information, which is expressed through words. In addition, the qualitative data collection captures "the richness and fullness" of information that cannot be done using the quantitative data collection method (Saunders, et. al., 2003). Thus, either technique is relevant to use depending upon the type of research study to be conducted. In addition, it depends on a researcher's skills, practice and creativity to match a research question to an appropriate data collection technique (Neuman, 2003).

In the study we collected data both of qualitative and quantitative nature. The data gathering was based upon the communications with the management at HAGS, interview with the supplier and sub-contractors, studying the internal HAGS documentation and field observation, see Figure 3.1. In particular, when studying the internal HAGS documentation quantitative data on lead and cycle times as well as product specifications were collected, whereas field observations resulted in both qualitative and quantitative data (cycle time measurement).

3.3.1 Interviews

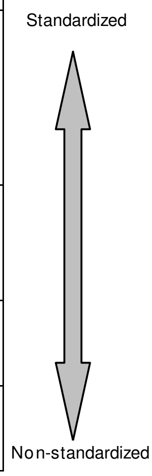
"The purpose of interviewing is to find out what is in and on someone else's mind. We interview people to find out from them those things we cannot directly observe" (Patton, 1990; cited in Hughes, 2002, p 209).

The interviews are helpful to gather valid and reliable data that are relevant to our research question and objective (Saunders, et. al., 2003). Yin (2003) argues that interviews are essential sources in case studies and are guided rather by conversations than by structured questions.

Different authors categorize interviews in different ways. In Table 3-1 we summarize the classification of interview by different authors.

Table 3- 1 The types and the degree of standardization of interviews

Interview classification by the authors				
Healey(1991); Healey & Rawlinson (1993, 1994) – cited in Saunders, et al. 2003	Saunders, et al. 2003, p.246-247	Wisker, 2001, p. 167-168.	Yin, 2003, p.89-92	Hughes, 2002, p.211
Standardized	Structured	Structured	Survey - structured questions as a part of the case study evidence.	Closed quantitative interview
	Semi-structured	Semi-structured, open-ended		Standardized open-ended interview
			Focused	Interview guide approach
Non-standardized	Unstructured	Unstructured	Open-ended	Informal conversational



It can be seen that the authors used quite the same classification, but they named it differently. We found it relevant to explain the interview as a tool of gathering information by referring the classification of Yin (2003) and Hughes (2002), see Table 3-1.

The focused interviews or the interview guide approach means that we prepare a set of questions in advance. According to Yin (2003), in such cases the interviews still remain open-ended and are a conversational manner. Hughes (2002) points to the Pros & Cons of the approach. The advantage is that the preparation of outline in advance increases the comprehensiveness of the data and makes data collection systematic. On the other hand, the disadvantage is that important topics may be inadvertently omitted.

According to Yin (2003), the open-ended or informal conversational interview approach is common in gathering information in case studies where the interviewer can ask not only about the facts of a matter but also an opinion about the events. The approach has the Pros & Cons either. According to Hughes (2002, p. 211), the advantage is that the open-ended interviews increase the salience and relevance of questions. The disadvantage is that the informal conversations imply that "different information will be collected from different people with different questions".

In our research we used the combination of the focused and open-ended interviews (Yin, 2003) or in other words, the interview guide approach and informal conversational approach (Hughes, 2002). We asked the questions not only from the interview guide. We also asked the questions that emerged during the conversation with the interviewees. In some situations we asked the interviewee "to propose the own insights into certain occurrences" (Yin, 2003, p.90). During the conversations with the managers at HAGS some new questions emerged and we were suggested to interview other persons and to look at the sources of evidence. By doing interviews we were able to understand the situation at HAGS in terms of production process, order fulfillment process, and what other parts are involved in the value chain of HAGS. However, not all the information we got were applicable to the present research due to our limitations of the paper.

We gathered the information by recording the interviews. According to Hughes (2002), there are three ways of doing that: note taking, tape recording and the combination of the two. In our case, to gather information we used the combination of the note taking and tape recording. It was as a help to minimize the possibility of losing information and also gave us the capability to re-check the collected data.

Choice of respondents

We conducted the study by the interviewing the particular respondents, see Figure 3-2. The choice of respondents determines the quality of the study. It is important to choose the right respondents to get the needed answers for the study.

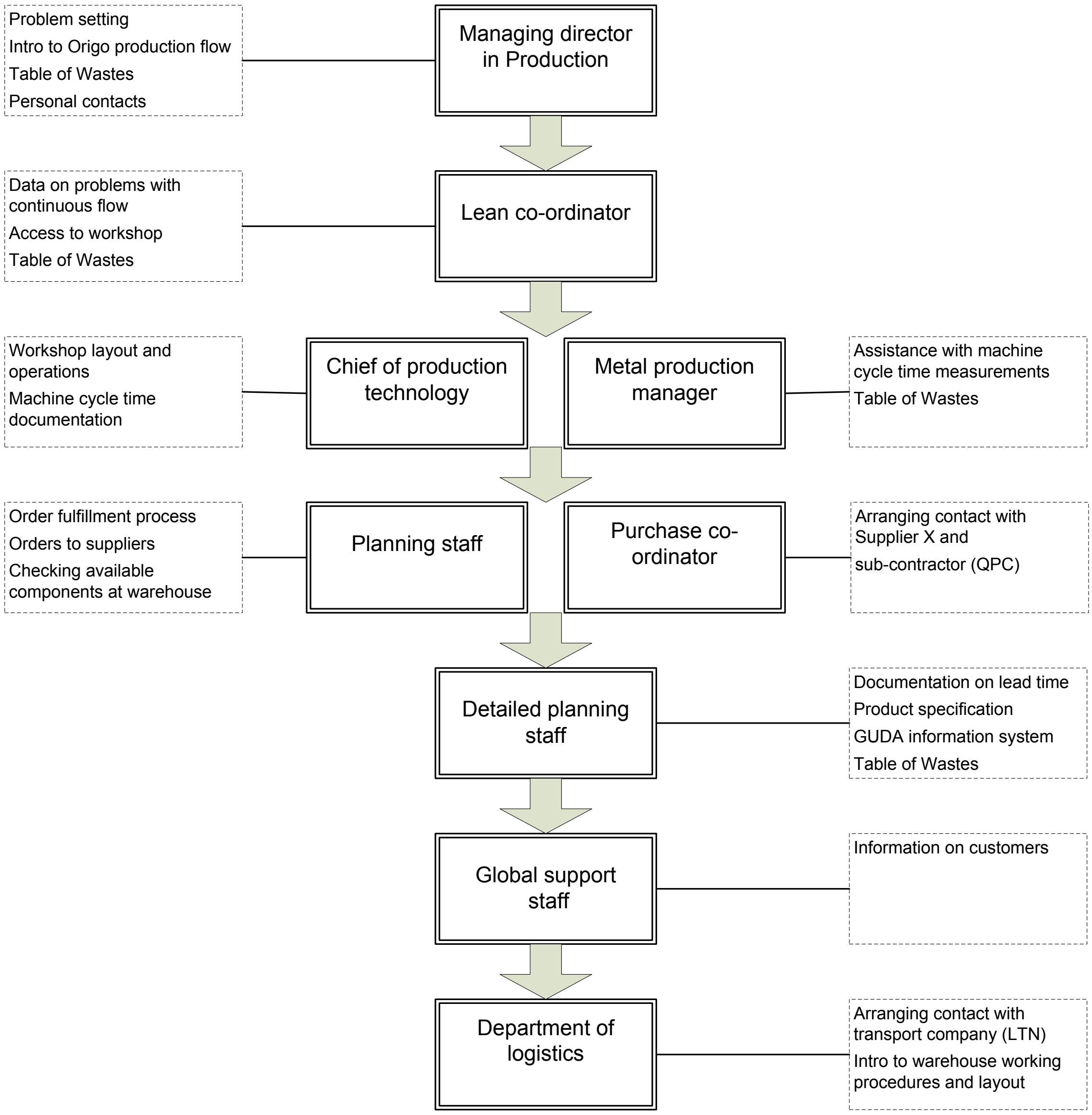


Figure 3- 2 Respondents interviewed in the case study, provided in the interviewing sequence

We interviewed in total nine managers at HAGS in several occasions. The interview included the personal communication and the telephone interviews with HAGS management.

The information boxes next to the respondents in the figure show what kind of data was gathered. Furthermore, we used the personal contacts at HAGS to interview Supplier X, sub-contractor QPC and transportation company LTN. However, the answers from LTN were not received.

3.3.2 Observations

According to Merriam (1998) the main difference between interviews and observations is that observations take place in the natural field setting and the data gathered about the phenomenon from observations is considered to be of the firsthand information.

According to Wisker (2001, p. 178), observation is a source of information that "enables to capture what people actually do rather that what they say they do". There are two main types of observation: participant observation and non-participant observation (Lacey, 1976; cited in Wisker, 2001). The participant observation means that the researcher becomes the part of the observed group, i.e the researcher will be employed for a certain period of time in a company. Non-participant observation means that the researcher observes the actions of others. Direct observation is used for the both types of observation (Wisker, 2001).

Observation can be used as a tool in research if it fulfils the conditions such as "1) to serve a formulated research purpose; 2) being planned deliberately; 3) being recorded systematically, and 4) being subjected to checks and controls on validity and reliability" (Kidder, 1981; cited in Merriam, 1998, p.95).

We conducted the study by using the non-participant direct field observations, see Figure 3.1. We visited the mechanical workshop and warehouse several times. The information we gathered was about the workshop layout and operations in the sequencing order. We were able to measure the cycle times of few production operations. The limitation we met here was that not all the Origo components were produced during our visits. Thus, we were not able to follow the methodology of mapping the value stream of the components. Next, we observed the working procedures and the layout in the finished products warehouse. The information gathered let us use value stream mapping method to construct the current state map of Origo value stream.

3.3.3 Secondary data

Secondary data is historical data that can be found inside the company, in library, on the Internet, *etc*. Usually, secondary data is collected for the other purposes than the data at hand (Zikmund, 2000). Documents are important at the data collection stage in a case study, due to their overall value. Secondary data is collected faster and at lower costs as compared to the primary data collection method (Zikmund, 2000). However, secondary data can be outdated and also the concern must be taken when interpretation of documents, since they are often prepared for another purpose and audience than that of the case study (Yin, 2003; Zikmund, 2000).

We used secondary data to understand the nature of product, .i.e. Origo. We studied the drawings and specifications of Origo components. Moreover, the documentation provided to us contained the sequencing order of the production processes, the cycle times and lead times of the components through the production processes in the workshop. Moreover, secondary data helped to understand the supply chain of HAGS and internal structure of HAGS. The internal structure of workshop, the organizational structure and the structure of HAGS supply chain were provided as secondary documentation.

3.4 Trustworthiness

All research is concern to be trustworthy in terms that the information provided there has to be valid and reliable in an ethical manner. The validity and reliability increase the extent of trustworthiness of the study. However, case studies have limitations in the issues of reliability and validity (Merriam, 1998). According to Hamel (1993), the limitations are due to the lack of representativeness and lack of rigor in collection, construction and analysis of the empirical information. It implies that studies are of the subjective nature (cited in Merriam, 1998).

3.4.1 Validity

Validity is very important in the cohesion between conceptual framework methods, questions and findings in the study. If the methods, approaches and techniques match with the research issues then the findings are likely to be valid, and in the opposite (Wisker, 2001).

There are four different tests of judging the quality of research that exists in the methodology literature: 1) *Construct validity*: the correct operational measures are established for the studied concepts. 2) *Internal validity*: testing a causal relationship by establishing the causal relationship between two variables. If a research does not take into account the third variable, which exists, a researcher failed to construct the internal validity. The internal validity is used for explanatory and causal studies only. 3) *External Validity*: deals with the issues whether study's findings can be generalized and the results applicable to another case study. Single case studies tend to have the external validity problems due to a poor basis for generalization. 4) *Reliability*: test of reliability means demonstrating the data collection procedures that can be repeated and the results would be the same (Yin, 2003).

In the study we constructed validity by using multiple sources of evidence. The interviews questions for HAGS and for the key partners were similar in the parts concerning the physical flow, information flow and planning issues and differed in the parts concerning the company specific information and relationships with their respective partner. In addition, after the interviews and direct observations at HAGS we wrote down the received information and sent it back to the managers for checking if we understood it right. Moreover, we tested the internal validity of variables, i.e. wastes by analyzing the causes of wastes and correlation between the wastes. We tested how well the theory about wastes matches the empirical information that we obtained from interviews and from the direct observation. However, it is hard to ensure the existence of the external validity due to the fact that the findings have to be tested at least two-three times on other cases. Even though, the developed methodology can be generalized to conduct other case studies.

3.4.2 Reliability

Reliability means the extent to which research findings can be replicated (Merriam, 1998). The objective of reliability study is to get the same findings if a researcher follows the same procedures. The goal of reliability is to minimize the errors in a study. In order to get reliable study, a researcher has to use case study protocol and develop case study database (Yin, 2003). According to Merriam (1998), reliability is based on the assumption that there is a single reality and when studying it repeatedly the findings will be the same. To increase reliability by observing phenomena, a common procedure is to have more than a single observer making an observation (Yin, 2003). In addition, the triangulation technique (when using multiple methods) can strengthen reliability and internal validity of the data collection and analysis of a study (Merriam, 1998).

To construct the reliability in the study we recorded the interviews either by using the recording device or by note taking. Moreover, we took digital pictures of the production process. We both observed the phenomena in the mechanical workshop and warehouse and this contributes to reliability of the study. In addition, we used the triangulation technique in determining what kind of wastes exists in the mechanical workshop.

As a final note, in order to confirm the wastes identified by the VSM method, we asked the managers of HAGS to fill in the ToW (Appendix 8). Comparison between the expert opinions and the results of the value stream mapping let us to find out if the conducted analysis resulted in the same wastes as indicated in ToW. This contributed into overall trustworthiness of the research results.

4 Empirical studies

The purpose of this chapter is to provide an introduction to the case study for Origo components flow at HAGS.

4.1 The development of Hags Aneby AB

HAGS is a Swedish manufacturing company that produces playgrounds and park furniture. The company was established in 1948 in the southern Swedish town of Aneby, fifty kilometers east from Jönköping. The three founders of the company realized that it was a need for both knowledge and products concerning children's playgrounds. The three men were skilled craftsmen: Sven Hultgren, Nils Andersson and Rune Gustavsson. The initials of their surnames formed the name of AB HAGS Mekaniska, which today called HAGS Aneby AB (HAGS presentation).

The goal was then, as it is today, to turn good theoretical knowledge about play into exciting, attractive and safe environments for both children and grownups. For more than 50 years HAGS looked at a play seriously with a great success. Figure 4-1 presents the evolution of the playgrounds.

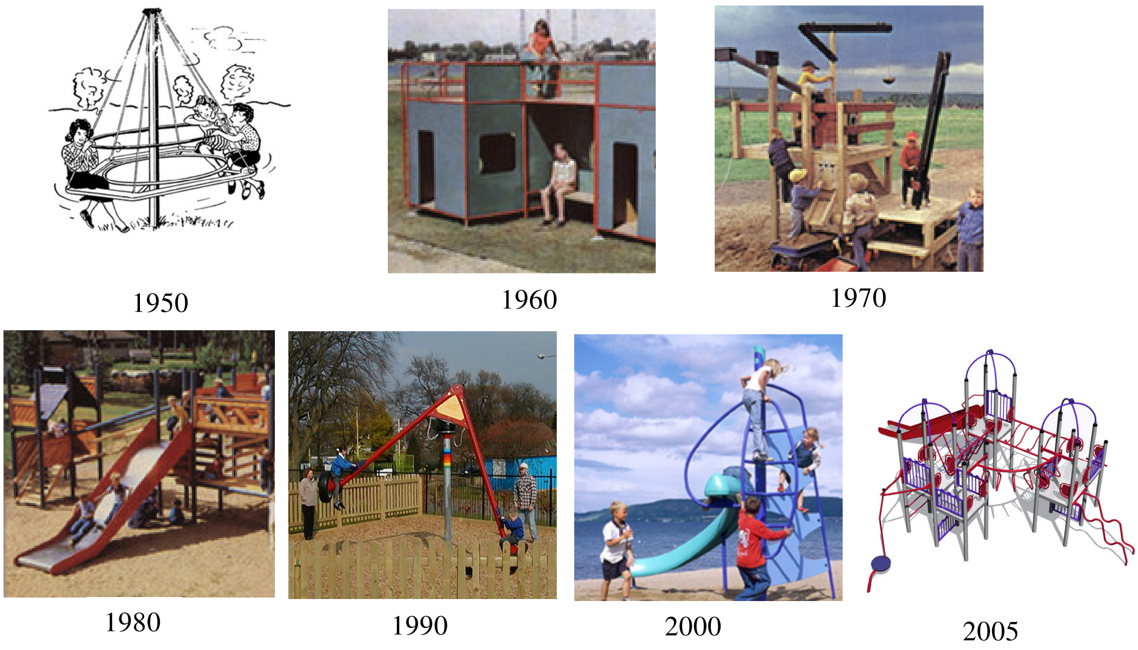


Figure 4- 1 The evolution of playgrounds at HAGS (source: HAGS presentation)

In the 1950's playgrounds were dominated by steel climbing frames, roundabouts and simple slides. By the 1960's designers began to think more of modular play. Poly Play was the first of these purpose-built play systems. During the 1970's the concept was developed further with wooden systems such as Stugby, Smaland, and Storland. The Stugby range gave children sand, wind and water play. Smaland marked the beginning of a number of systems that were refined over the past 25 years. Like the current UniPlay system, Smaland and Storland were based on flexibility and the concept led the field in the industry all over the world. Throughout the 80's the trend was for modular products like Playland and standalone products such as the revolutionary Mobilus. From the 1990's the refinement began of the play system concept with the development of further play functions that span until nowadays. Today the UniPlay (designed for children of 3-12 years) and UniMini (designed for children of 2-5 years) systems are the biggest names in the market and set the standard for playground environments. Now the possibilities are virtually unlimited for building attractive and exciting playground by combining the components from various series of products (HAGS presentation).

Today HAGS became one of the most successful companies in its field, i.e. the manufacturing of playgrounds equipment and park furniture. The ideas from 50s are still valuable: to turn good theoretical knowledge about play into exciting, attractive and safe environments for both children and grown ups. It is a background of company's five cornerstones philosophy - Function, Safety, Quality, Environment, and Design. In 1993 HAGS was certified in accordance with ISO 9001 and in 1997 the company was certified to ISO 14001. HAGS experienced that quality same as environmental issues must be treated in a clear, structured way that do not conflict with the defined goals of the company. Thus, HAGS worked with each section of our operation, evaluated, and created an environmental program to minimize the impact on environment. Another important contribution of HAGS work for a better environment is to set environmental demands on its suppliers and other co-operators (Hags homepage).

As a basis for safety, all the equipment was approved by the German TÜV certificate (Technischer Überwachungs-Verein). The TÜV certificate has the most extensive and advanced testing and approval procedures in the world. With a help of the safety standard the company seeks to create the safest possible playgrounds without detracting from their pedagogic value or, indeed, the attraction they hold for children (HAGS homepage).

4.2 Present-day HAGS

HAGS has the representation offices in more than 50 countries worldwide. PlayPower Incorporated is a mother company of HAGS. In turn, HAGS in Aneby owns companies in UK, Spain and Germany. The Concern of HAGS has an annual turnover of approximately 600 MSEK together with the daughter companies in UK, Spain and Germany. The turnover of HAGS is 450 MSEK. The Concern of HAGS has total of 275 employees including the daughter companies. In Sweden HAGS has total of 200 employees including the manufacturing facilities and Head Office in Aneby, shown in the picture of Appendix 1. The manufacturing facilities consist of six shop floors such as carpentry, wood treatment, mechanical workshop, assembly, packing, and warehousing (HAGS presentation).

Core competence of HAGS is the manufacturing playgrounds and park furniture that goes together with improving quality and developing even more reliable technical construction solutions (HAGS presentation).

The vision of HAGS is to be "the number one of manufacturing playgrounds that inspires a new generation" (Personal communication at HAGS, 2007-11-22).

The management structure is presented in Figure 4-2, where departments visited during data collection are made in dotted pattern.

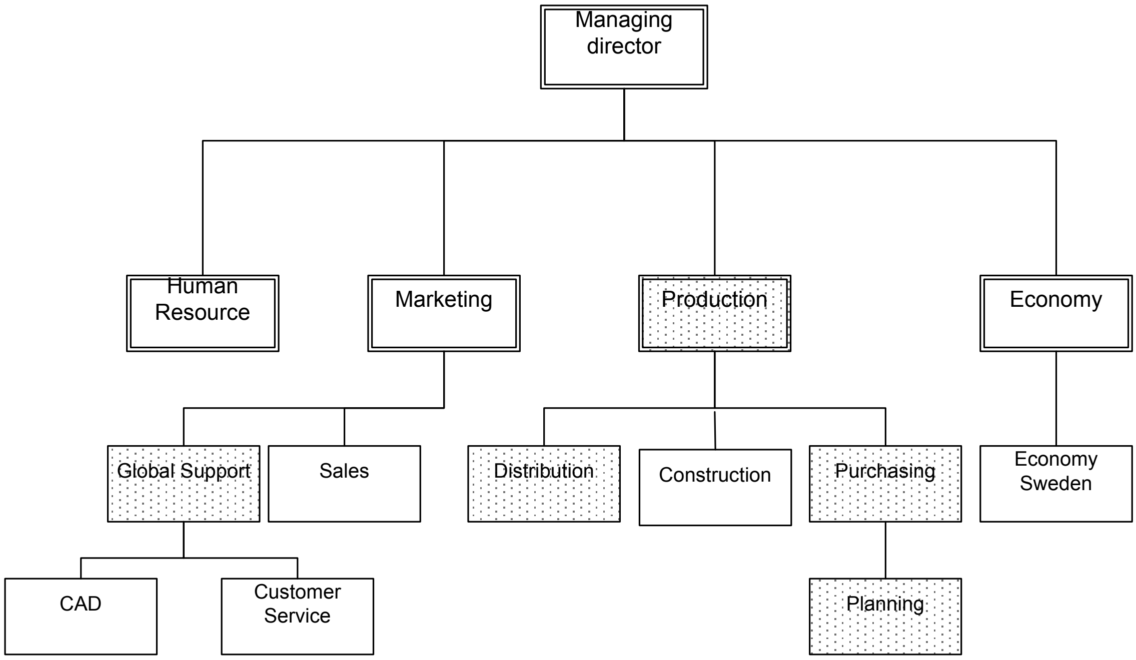


Figure 4- 2 The management structure at HAGS with departments visited during data collection shown in dotted pattern

HAGS has approximately 400 suppliers. However, we limit our discussion to Supplier X, which supply raw material, i.e. precut steel tubes to HAGS mechanical workshop. "HAGS buys approximately 80 percent of needed precut steel tubes from the Supplier X" (Interview with Supplier X, 2007-11-30). The criteria of choosing the supplier were its flexibility, reliability, and the quality of raw material.

HAGS chose few sub-contractors, such as painting company QPC and a number of logistics companies. We limit the discussion to transportation companies LTN, DHL and Schenker. The criteria of choosing the sub-contractors were costs, geographical proximity, flexibility, quality and reliability.

The annual consumption at HAGS production facility including the six shop floors such as carpentry, wood treatment, mechanical workshop, assembly, packing, and warehousing is listed below:

- 3,000 cubic meters sawn timber
- 140,000 meter glued timber mast
- 800,000 kg sheet metal
- 850,000 kg steel material
- 125,000 kg stainless steel
- 22,000 used car tires
- 90,000 liter paint
- 21,000 square meters HPL
- 23,000 square meters Plywood
- 3,1 million plastic sleeves
- 7,2 million bolts and screws
- 200,000 meter chain
- 1,200 truck for delivery

- 80,000 cubic meters goods delivers

The list was updated in March 2006 (HAGS presentation).

4.2.1 Products of HAGS

HAGS in Sweden offers product solutions in the area of traditional steel and wooden play equipment. The offerings are divided into Play, Planet, and Plaza playing systems, see Figure 4-3. The product range offered by daughter companies is slightly different. The product categories are the same including the standard offerings such as play ground equipment and park furniture. Other offerings are more tailored to the country. For example, HAGS Play LTD in UK, offers skate parks (HAGS UK homepage). (www.hags.co.uk).

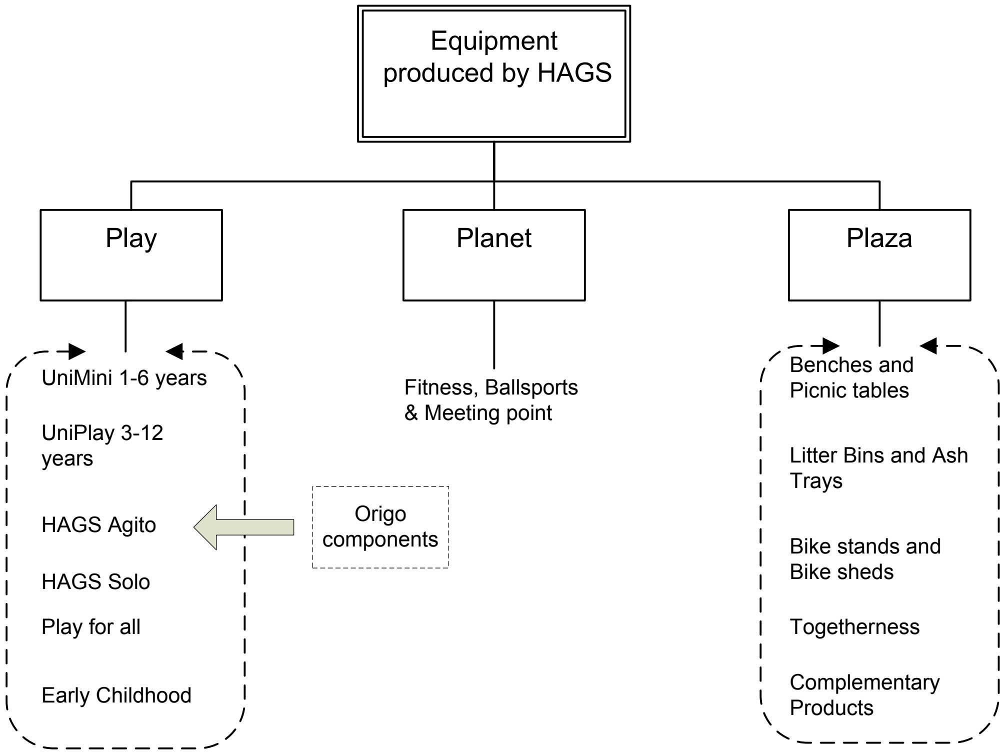


Figure 4- 3 Equipment produced at HAGS (Source: adapted from HAGS homepage)

The group of Play equipment is specially adapted for children of different ages. The play systems such as UniMini, UniPlay and HAGS Agito differ in their play functions. Besides these play systems the company has a large range of other play equipment such as early childhood play equipment, swings and swing seats, larger spring toys (cars and boats, slides, activity circuits, balancing equipment, climbing wall and nets, *etc.*). The chosen Origo family product is from Play group.

4.2.2 Introduction of the product family

We selected to follow the flow of the Origo product family, see Figure 4-4. Origo forms the central part of the entire Agito system (HAGS homepage). All the other components of Agito are attached to the Origo part. Agito belongs to Play products group. In Appendix 9 we present the Origo in the Agito playing system.

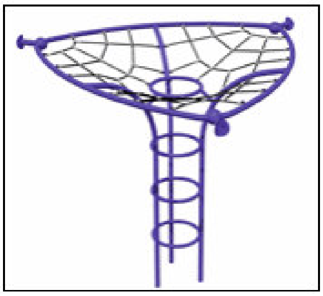


Figure 4- 4 General view of the assembled Origo components.

4.3 The Value Supply Chain of Origo at Hags

This chapter introduces main actors that are involved in the value flow of Origo family product flow at HAGS.

The actors of HAGS value chain are connected through the Origo flow. There are seven main actors, from the raw material supplier to the end customer, that are involved in the value flow of Origo, see Figure 4-5.

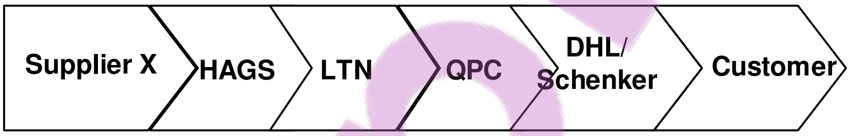


Figure 4- 5 Main actors in the Origo value flow of HAGS

4.3.1 Supplier X

We name raw material supplier as Supplier X due to confidential concerns. Supplier X is located in many countries, including Sweden, Denmark, Estonia, Finlan, Latvia, Lithuania, Norway and Russia. Supplier X offers the largest and the most comprehensive range of steel tubes in Scandinavia and handles more than 100.000 tons of tubes yearly. It offers not only warehousing and shipment services but also provides production support, logistics and business solutions (Supplier's X homepage). During our study we contacted the central head office of Supplier X.

The Supplier X has 280 employees. It became HAGS' supplier since 2004. The company considers HAGS as an important customer. The managers pointed that HAGS was "an interesting market for Supplier X with high demands that put a pressure on us and gives us the possibility to develop as a supplier" (Interview with Supplier X, 2007-11-30).

HAGS buys precut steel tubes and special profiles from Supplier X. As compared to the total volume of raw material sold, Supplier X sells about 70% of steel tubes and special profiles to HAGS (Interview with Supplier X, 2007-11-30). We limit our discussion to steel tubes. Steel tubes and steel pipes are used in the paper as synonyms.

HAGS made a special agreement with Supplier X about special demands on the steel tubes and delivery times (Interview with Supplier X, 2007-11-30). The special demand is that the surface of steel tubes has to be galvanized. Through the galvanization process the steel tubes are covered with a very thin layer of Zink, which protects the tubes from rust but it makes the metal processing work much difficult (Personal communication at HAGS, 2007-11-06).

Supplier X has the expectation to receive from HAGS ”larger call-off quantities that contributes to fewer deliveries”. In addition, Supplier X feels that it has “a good relationship with HAGS today and the ambition is to be able to offer more customer related solutions in future”. “To provide proposals for new improved solutions is also a main customer subject” (Interview with Supplier X, 2007-11-30).

4.3.2 HAGS mechanical workshop

According to HAGS, the total volume of components produced in the mechanical workshop amount to 2.8 millions items ranging from screws that cost ½ SEK per piece to large items that cost 40.000 SEK per piece. HAGS mechanical workshop involves the metal works only. “50 persons work at the mechanical workshop out of 150 who work in the other production workshops (carpentry and wood treatment), packing and warehousing” (Personal communication at HAGS, 2007-11-22). The metal components pass through the different production processes such as bending & cutting, drilling, punching, beveling, and welding. There is also one welding robot. The chosen components of Origo flow through the bending machine, beveller trimmer, drilling machine and welding operation. All of the works necessary to produce Origo are based on the handwork, i.e. without using the welding robot.

The production of different Origo components is carried out in parallel. It means that the flow of Origo components consists of three parallel but separated flows in the mechanical workshop. The lead time of all Origo components is two weeks in the mechanical workshop. After the two weeks in the mechanical workshop the Origo components are shipped to the sub-contractor QPC for the surface painting.

We will talk about QPC in chapter 4.3.3. The shipment is performed by the outsourced logistics company LTN that will be discussed in chapter 4.3.4.

4.3.3 QPC

Quality Powder Coating AB (further we refer it as QPC) is a sub-contractor of HAGS. QPC makes the surface treatment in the painting workshop. It is quite small and young company. QPC was operating for 15 years and had 17 employees (Interview with QPC, 2007-11-27).

According to the QPC, the company became a sub-contractor of HAGS since August 2003. QPC considers HAGS as a “very important customer”. The sales of surface treatment service, that is painting, provided to HAGS amount to 30% of QPC’s annual sales. Further, the company considers itself as a good sub-contactor of HAGS, because "we are one of very few powder coatings in Scandinavia to take on the size of components HAGS has and for their approval of our pre-treatment". In addition, QPC expects "a long-term collaboration which benefits both companies" that allows "to keep up an open minded business related communication" (Interview with QPC, 2007-11-27)

The painting process involves main steps such as components washing, nano-ceramic surface treatment, which gives better adhesion and better corrosion protection. Then the components pass dry-oven and temper-oven. The up- and down turned conveyors have 300 meters of total length. The components pass throughout the painting process in approximately $4^{1/2}$ hours (QPC homepage).

According to the agreement between HAGS and QPC, HAGS sends semi-finished components for the painting three time per week. The components have to be finished in a week for the standard colors. HAGS defined a set of standard colors for its products. Usually, the standard colors are combination of warm yellow and Agito blue. In our case, Origo family products, there is just one standard color that is Agito blue. If a customer chooses rare colors, the lead time of components will be three weeks and the price increases by about 15 percent. Moreover, QPC has a policy to charge 1100 SEK for the painting system changeover costs if the order of painting is lower than 5000 SEK. However, it is not concern of HAGS, because the orders of painting always exceed 5000 SEK (Personal communication at HAGS, 2007-11-06).

4.3.4 LTN

Tranås Åkeriet AB consists of seven road carriers, and one of them is transportation company LTN. LTN stands for "Lager Transportation i Norden". The company is established in 2004. The number of employees is 10 (Tranås Åkeriet homepage).

LTN is in charge of the forward and backward transportation between HAGS and QPC for the delivery/picking up the semi-finished components. The selection of LTN is made by the logistics department at HAGS. The decision is mainly based upon the price consideration. The special contract between HAGS and QPC determines that the responsibility of LTN is to pick up/drop a trailer at HAGS. The trailer is filled up with the semi-finished components to be shipped to QPC. LTN comes to HAGS to pick up a full trailer and to drop the empty one on the fixed days, i.e. three times per week, at any time during the day. In addition, LTN is in charge of loading the trailers with the orders at HAGS and in the rail station that are appointed to customers. In some cases LTN delivers customer orders in Sweden (Personal communication at HAGS, 2007-11-22).

4.3.5 Outbound Logistics Companies

We identified the outbound logistics providers as actors in the HAGS value chain. However, our focus is based upon the inbound order flow. Thus, we do not elaborate much on the outbound logistics providers in the paper.

To ship the products to the customers, HAGS mainly uses the logistics providers such as DHL and/or Schenker. The choice of the logistics providers are based mainly upon their geographical capability to reach the customers worldwide. HAGS signed the agreements with DHL and Schenker for the transportation services. According to the agreement HAGS books the transportation from DHL or Schenker one day in advance the order to be shipped. The logistics providers come to HAGS few times per day to pick up the orders. The rationale of picking up the orders few times per day is that the logistics providers pick-up orders by destinations (Personal communication at HAGS, 2007-11-22).

4.3.6 Customer

The customers of HAGS are divided mainly into the groups such as 1) private; 2) governmental companies; 3) counties; 4) hotels; and 4) construction companies (e.g. NCC, Skanska) that are selling houses and playgrounds as a package. The counties are the largest customers of HAGS. They amount to approximately 60-65% of the all customer groups. In addition, the customers of HAGS are located not only in Sweden but also globally, for example, in Africa, Europe, Asia, *etc.* (Personal communication at HAGS, 2007-11-22).

We have to mention that the customers are not the final customers, except the private ones. The customers from the other groups, i.e. governmental, counties, hotels and construction, order the playing systems for end users. The ordered playing systems are installed in the parks and other recreation zones. Thus, the end users are all people who use the equipment.

4.4 Order fulfillment process

Order fulfillment process at HAGS is complex due to the fact that the company performs a wide range of activities that are necessary to deliver the product to the customer. The order fulfillment process is shown in Figure 4-6. It involves the main processes such order entry, processing, manufacturing, packing and picking, and shipment.

Order Entry

A customer places an order either by phoning, faxing or by sending e-mail to the customer service of HAGS. Swedish customers, which order first time usually place orders through telephone. The "old" customers and export customers send orders via e-mail. Fax is not often used by a customer. Once an order reaches the Customer Service, it is entered into the business system GUDA. The GUDA business system is the internal IT system shared by all the departments at HAGS. All the departments have access to the GUDA system. (Personal communication at HAGS, 2007-11-22).

The GUDA system is the basis of information transmission inside HAGS. The GUDA system includes the information about product articles, scheduled production with its starting week, planned finishing week and the week when the production is actually finished, order numbers, customer numbers, volume of orders, stock levels and safety stocks, EOQ (Economic Order Quantities), and production lead times. Thus, the data in GUDA system is updated immediately, once an order enters it. The data can be seen and shared right away by all the departments. The departments of HAGS use different data from GUDA because they have different tasks and they work on different orders. When an order is received, the Customer Service checks in the GUDA system the availability of components and provides the customers with possible day for delivery.

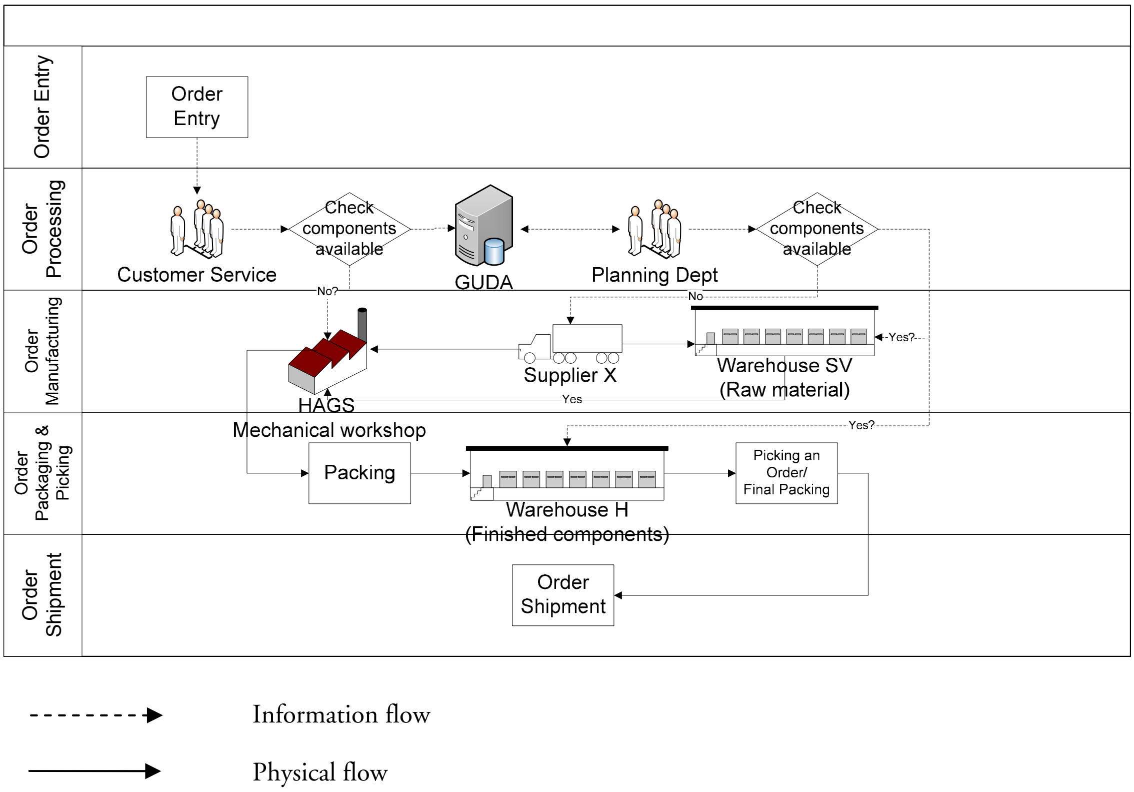


Figure 4- 6 Order fulfillment process

Order processing

Direct contact between the Customer Service Department and the Planning Department occurs only when a customer places an urgent order. In this case, the Customer Service personnel contact the planners for the detailed information about the possible production lead time (Personal communication at HAGS, 2007-11-22).

In general cases, Planning Department checks in the GUDA system 1) the components available in finished goods warehouse H, which is located on the territory of HAGS; and 2) availability of raw materials in warehouse SV, which is located 2-3 km away from HAGS. Only low frequency raw material is stored in the warehouse SV that is purchased to achieve the economy of scale. If the required components and/or raw materials are available in stock, the planners make a reservation in the GUDA system, so that nobody else can take them to produce other playing systems. In case if some components are to be produced, the planners place orders to Supplier X. The lead time of the requested raw material is one week. Supplier X takes care of the transportation to HAGS. The information exchanged between the Planning Department at HAGS and Supplier X includes the delivery issues and the quality feedback. Once the raw material is delivered the manufacturing process starts (Personal communication at HAGS, 2007-11-22).

Order manufacturing

The orders are manufactured in the mechanical workshop at HAGS. "The production of HAGS is based upon both the annual production forecasting and the customer orders. The proportion of production between forecasting and customer orders varies all the time.

During the low season, which is from November until April, the production is based more on forecasting. And respectively, during the high season, which is from April until November, the production is based more on customer orders" (Personal communication at HAGS, 2007-11-22).

The order manufacturing includes the activities such as production processes at the mechanical workshop, painting process at QPC and transportation services described below.

The mechanical workshop receives the weekly orders from the Planning Department. The orders are printed on the paper and carried to the Detailed Planning Office in the mechanical workshop. The managers in the mechanical workshop have an access to GUDA, but all production works are generated by the planners (Personal communication at HAGS, 2007-10-25).

The work priorities are based on the order priorities. The priorities of work in the workshop are generated by the Detailed Planning Office (Personal communication at HAGS, 2007-10-25).

There are three planning tables in the workshop where the detailed planner places the paper cards with the information about the working tasks. The detailed planner also checks the work tasks with high preferences. If there are tasks with high preferences, the paper card will be marked with the red stamp. The work coordinator helps to the detailed planner to maintain the planning tables. The work coordinator picks the paper-cards, that is, the working tasks, and delivers the needed components to the process operators to work with. The lead time of the components through the production processes in the mechanical workshop is two weeks (Personal communication at HAGS, 2007-11-06).

Order manufacturing includes the painting works at QPC. After the components went through the production processes in the workshop, they would be shipped to QPC for the painting. The lead time of the components at QPC is one week for standard colors. In our case, Origo's the standard color is Agito blue. If a customer wants other color, the lead time will increase up to three weeks (Personal communication at HAGS, 2007-11-22).

Furthermore, the order manufacturing process involves the transportation. The logistics company LTN takes care of the transporting the components from/to HAGS to/from QPC. LTN comes to pick up the trailer at HAGS three times per week. The time to pick up the trailer is flexible. The lead time of transportation is 45 minutes to ship the components from HAGS to QPC, and 20 minutes for changing trailers (Personal communication at HAGS, 2007-11-06). Figure 4-6 does not show QPC and LTN since we consider the companies are as a part of the whole order manufacturing process.

Order Packing and Picking

When the painted components arrive from QPC, they have to be packed. Each of the components has to be packed separately. The activity is performed in the premises nearby warehouse H. Once the components are packed they are placed to warehouse H for storage during the low season. During the high season the components go for the final packing and are shipped to customers (Personal communication at HAGS, 2007-11-22).

The order picking process is carried on in the same warehouse H, which is located in the HAGS industrial area. Once the components are ready for shipment to a customer, they have to be packed in boxes, that is, final packing is performed (Personal communication at HAGS, 2007-11-22).

Order Shipment.

To deliver the playing systems to both domestic and international customers HAGS uses a number of logistics companies. In the study we limit the discussion to LTN, DHL and Schenker logistics providers. Usually DHL and Schenker companies ship the products outside Sweden and LTN engages in the delivery of the products within Sweden. The logistics manager contacts DHL or Schenker service provider one day before a customer order is ready. The next day the logistics company picks the customer order for shipment. The service providers, DHL and Schenker, might come many times per day to pick up goods for deliveries. It depends on the location of the final customer. When the service provider picks up the order, the logistics department sends a notice about delivery time to the customer (Personal communication at HAGS, 2007-11-22).

5 Analysis

The analysis is based on the three lean principles: specify value, identify value stream and make value flow. The analysis starts with a short discussion how HAGS customers perceive value. Next, we visualize the value stream of Origo components, including the analysis of time frame and ownership in the order fulfillment process. The main focus will be on the waste identification in the flow of Origo and the solutions to reduce the influence of identified wastes. Furthermore, mapping tool Decision Point Analysis will be applied to determine the decoupling point in the supply chain of HAGS. In addition, HAGS positioning in terms of supplier relationships will be analyzed.

5.1 Specify Value

According to Womack and Jones (1996), the starting point for lean thinking is to define value that is created by the producer. One of the value definitions in Table 2-1 specifies the value as "a property of a product or service that the customer cares about and would be willing to pay for" (Whicker, Bernon, Templar & Mena, 2006, p.2.).

According to the definition, *value* is the playing systems that HAGS produces. *A property of a product or service that the customer cares about* is the high quality and safety playing systems with wide range of functions and attractive design. The customer *would be willing to pay for* a possibility to create customized playground solution. However, the process of building an individual playground requires knowledge of how components and play functions should be organized within the combination. There exists some limitation because not all the components can be combined in all ways. The staff of HAGS assists the customer in choosing the individual playground that could fulfill the product specification and the customer needs. Through the cooperation between the customer and HAGS it is possible to create a unique playing system.

In summary, the value is the high quality and safety playing systems with the wide range of functions and attractive design. The customer is willing to pay for the possibility to create an individual solution by combining components in many ways.

5.2 Identify the Value Stream

The reason to identify the value stream is to search for *muda* (waste). By choosing the specific products and mapping out every step in the order fulfillment process it will be possible to identify *muda*. The rationale behind it is that only measurable activities can be properly managed. Moreover, if the activities necessary to create or produce a specific product cannot be precisely identified and analyzed, they cannot be improved or eliminated (Womack & Jones, 1996).

We defined the activities necessary to bring Origo from the stage of raw material to the stage of finished components. However, according to the limitation we set before, we focus on the value stream of Origo components from the stage when raw material enters HAGS mechanical workshop until the moment when the finished components have to be shipped to the customers. Figure 5-1 outlines the value stream for Origo family components.

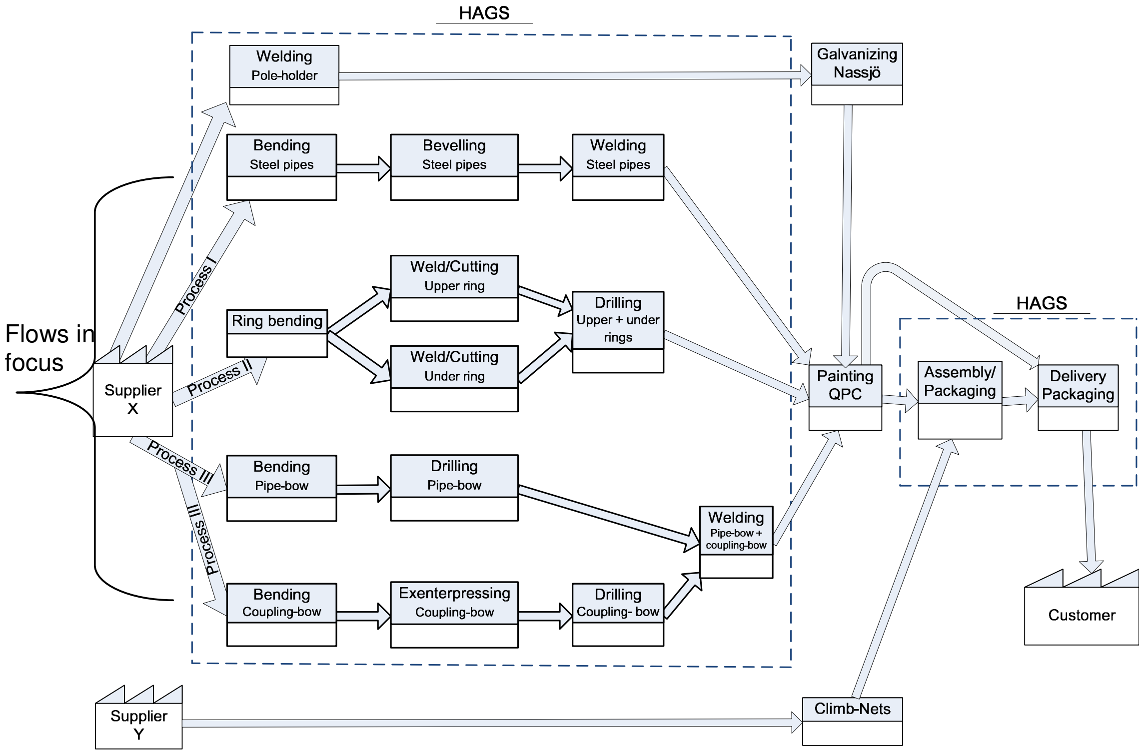


Figure 5- 1 Schematic picture of the value stream for Origo components

The value stream for Origo components consists of several flows. However, we will look closer at the flows that we named as Process I, Process II and Process III. The key actors, such as Supplier X and sub-contractor QPC, are involved in the value stream of Origo in the focused processes.

Supplier X is considered as having the largest stock of precut steel tubes in whole Scandinavia. As we have mentioned before the managers of Supplier X pointed that HAGS is "an interesting market for Supplier X with high demands that puts a pressure on us and gives us the possibility to develop as a supplier" (Interview with Supplier X, 2007-11-30). Supplier X is a flexible company that responds to its customer needs. HAGS has requirements for the steel tubes: they have to be precut in different lengths and vary in diameters. The special requirement is that the precut steel tubes have to be galvanized. The galvanization protects the steel tubes from rust. To fulfill the requirements of HAGS, Supplier X sends the steel pipes for galvanization to a company, located in Finland. Since we set a clear limitation, the company in Finland is out of our scope.

The sub-contractor QPC paints the components for HAGS. HAGS cannot perform the activity by itself due to its complexity and incurred costs. To cover semi-finished components with a color necessary to employ the high cost technologies and have skilled employees. HAGS has no resources to paint the metal components itself, thus, the activity is outsourced to QPC. Only the metal components are painted at QPC. HAGS produces many wooden products that are painted in the wooden workshop at HAGS. Origo product does not include wooden components, which are therefore not included in to consideration.

The key actors in the value stream are connected in the order fulfillment process. Figure 5-2 visualizes the time frame of order fulfillment process.

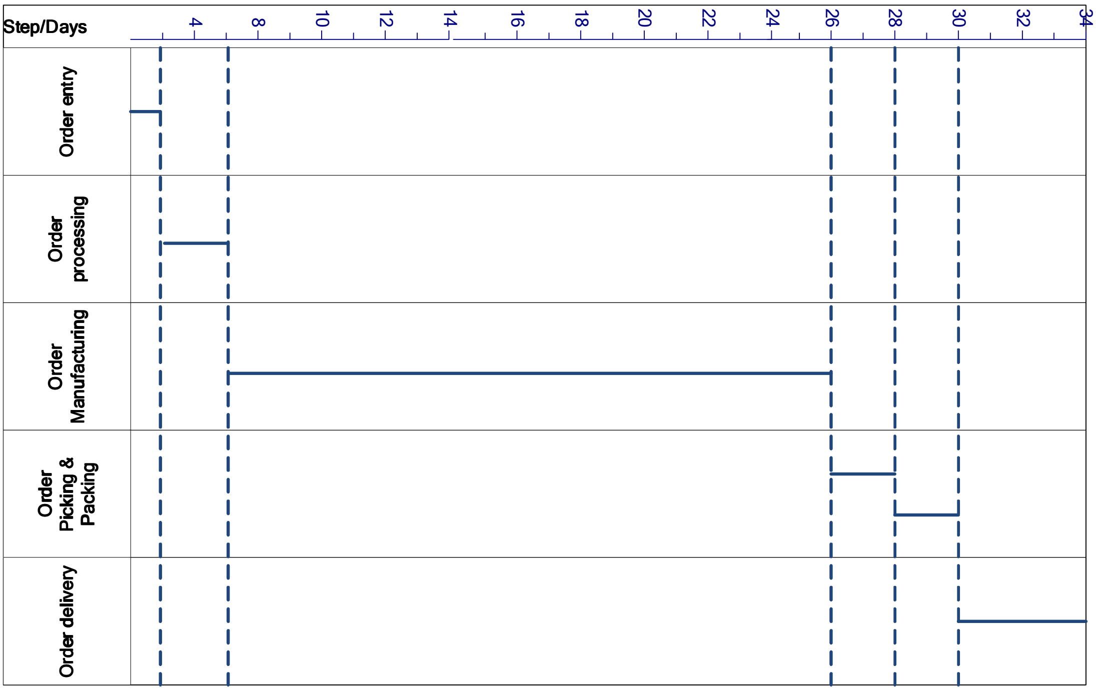


Figure 5- 2 The time frame of order fulfillment process

The order entry takes form 0 to 2 days depending on the customer's ability to take quick decision what he/she needs, see Figure 5-2. The order processing takes 4 days, including the contacts with suppliers, checking available raw material and ordering if it necessary. The order manufacturing at HAGS takes 20 days, including the painting activity at QPC. The order picking takes 2 days and packing takes another 2 days if the there is a customer order. Order delivery takes on the average 4 days, depending on the customer location. Thus, the total number of days spent on order fulfillment process is 34 days.

The situation is different when HAGS lacks raw material in-house to produce the play-ground, see Figure 5-3. From Supplier X the lead time of raw material is a week. It implies that the mechanical workshop postpones the production for a week until it gets the input. Then, the lead time of raw material in the workshop will be a week also. The components have to be processed faster, i.e. within a week.

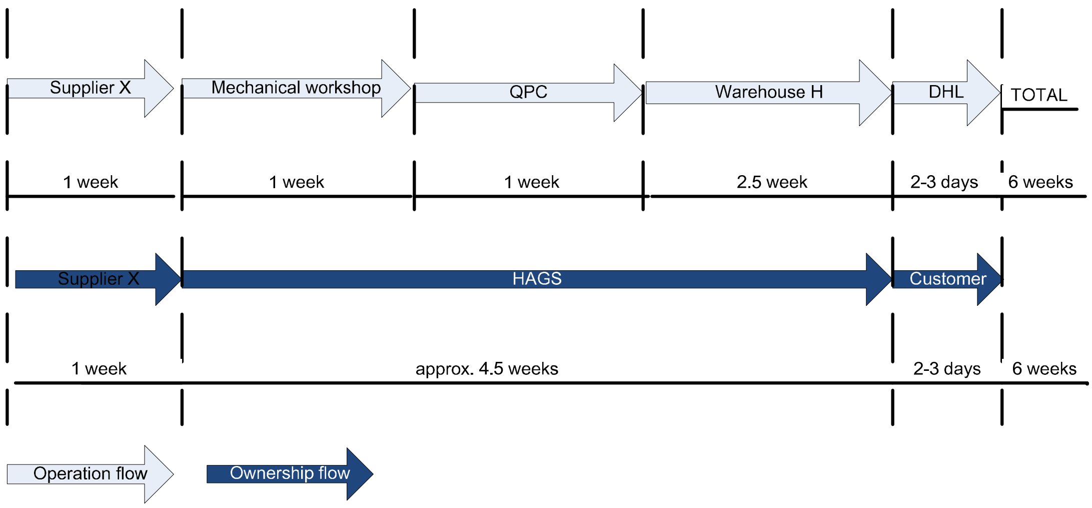


Figure 5- 3 Operation and ownership flows of Origo for a customer order

Next, Figure 5-3 shows the flow of ownership through the value chain starting from the stage of the precut steel tubes and ending by finished components, which are ready for installation. The ownership of the components incurs risks and extra costs for HAGS. Most of the time, the components are the property of HAGS.

To sum up, Supplier X is the company that produces the precut steel tubes and QPC is the sub-contractor for the surface treatment of semi-finished components. Both companies are the key actors in the value stream of Origo components, which are connected closely in the order fulfillment process. The time frame differs depending on the accessibility of raw material; however, the components are the property of HAGS most of the time in the order fulfillment process.

5.3 Make Value Flow (I): analysis of the Current state map

In order to identify wastes we map the current state flow of Origo family components, see Figure 5-5. In Appendix 4 the icons used in the figure are explained. As we have shown in Figure 5-1, the flow of Origo consists of the three parallel flows, namely process I, process II and process III:

- Processes I – the flow of steel pipes, see Figures 5-4, Figure 5-5 and Appendix 5. The flow includes the three bended steel pipes, which are assembled vertically.
- Process II – the flow of rings, see Figure 5-4 and Appendix 6. The flow includes the four rings. Three of them are identical (the lower rings) and the forth, the upper ring, has the small ears to hold the net.
- Process III – the flow of three pipe-bows and one coupling-bow, see Figure 5-4 and Appendix 7. Note, the coupling-bow is shown in Appendix 9.

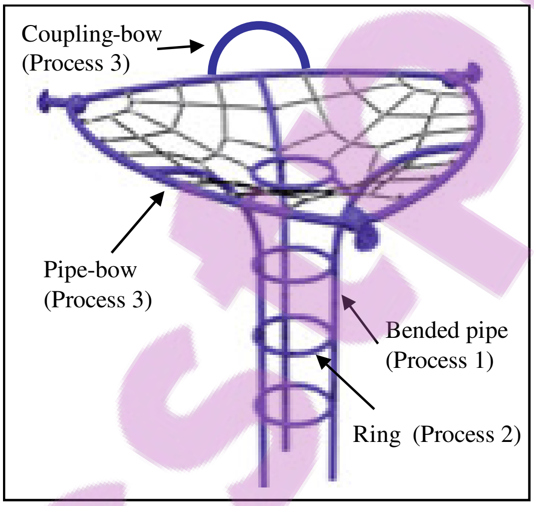


Figure 5- 4 Main Origo components and associated production processes

Here we provide the clarifying information concerning the items of the current state map in Figure 5-5 and Appendices 5, 6 and 7. The information box of customer shows the requirement of Origo components per one month. We derived the numbers from the forecasting per one year. Next, we show Supplier X and we assume the supplier delivers the precut steel pipes directly to the mechanical workshop at HAGS. In the upper middle part of the figure we show the departments at HAGS involved in the order fulfillment process.

The departments are involved by accessing the information in GUDA information system. Under the departments, the value streams of the Origo components are shown, which flow through the production processes. Please note, that the packing process has two cycle times. The first cycle time (3.5 min) stands for the primary emballage in plastic of each component, and the second cycle time (38 min) accounts for the time for the final packing. The final packing means that all the components, which belong to the same product, are packed into the same box. The final packing we count as 8 complete box-sets, since in each production process a big series of respective components is produced.

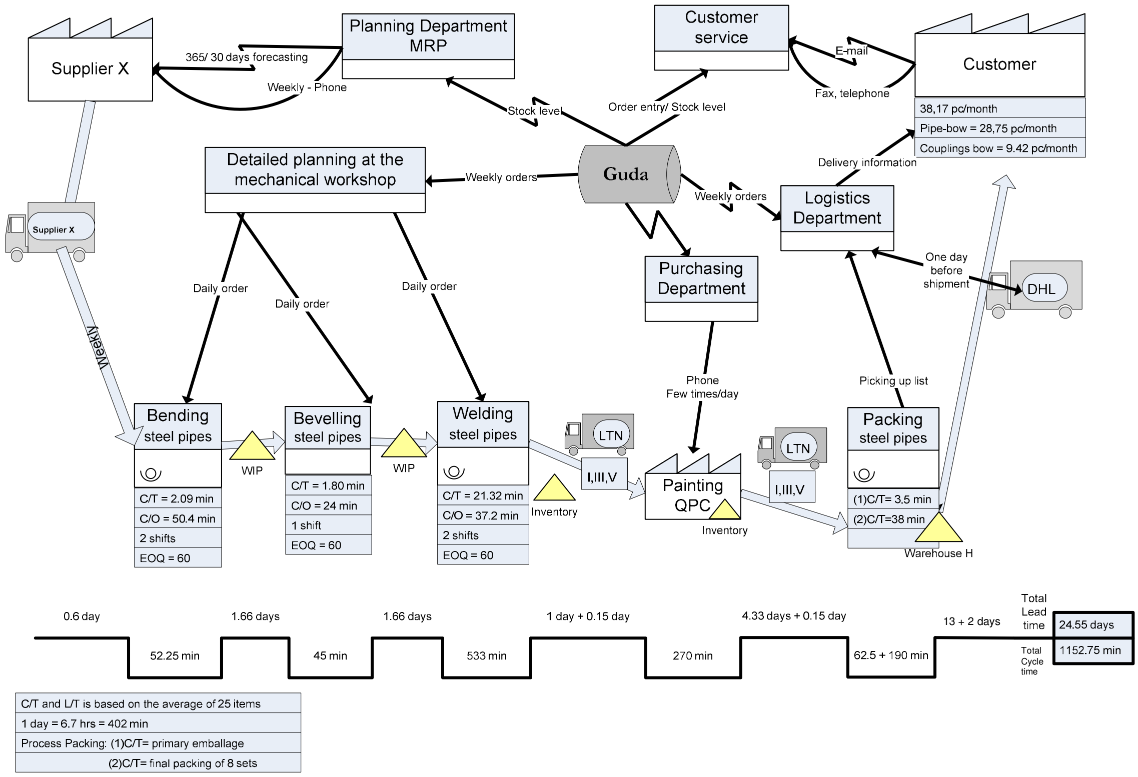


Figure 5- 5 Process I - VSM of steel pipes at HAGS (for all the processes see Appendices 5-7)

As soon as the customer order reaches HAGS' customer service it is placed in GUDA information system. The departments involved in the order fulfillment process plan resources and give orders to mechanical workshop. Planning department orders some raw material from Supplier X. The supplier delivers the precut steel tubes to the mechanical department at HAGS. Then, the input goes through to the production processes in the workshop, then it goes to the painting operation at QPC and comes back again to HAGS for packing and storing. The purchasing department deals with QPC on the painting orders, and the logistics department orders the transportation to the customers.

Next, we counted the total lead time (L/T) and the total cycle time (C/T) of Process I flow; see Figure 5.5 and Appendix 5. The total L/T is 24.55 working days. We consider a day as the net working day, which has 6.7 working hours. The total C/T is 1152.75 minutes, that is, the value added time. Thus, the difference between the total L/T and the total C/T is 21.68 days. It means that it takes only 2.87 working days (1152.75 min) to produce 25 items of steel pipes. However, according to our investigation it took 24.55 working days for the all activities in the process I.

There is quite the same proportion between C/T and L/T in the process II and the process III, see Appendix 6 and Appendix 7. The reason here is that HAGS produces the components according to EOQ model (economic order quantity). The workshop produces the components in batches in order to use machines economically. For example, EOQ is 60 for the process I. The forecasting for the one year production is 345 pieces. Thus, 345/60 = 5.75. It means that Origo components are produced 5.75 times per year. To produce more often incurs extra costs for the set up time of machines. The set up time or change-over time of machines will be the same for one component or twenty components to be produced. Thus, to use the machines in economical mode, the workshop set the EOQ for every component process. If there is no direct customer demand for the playing system, the components average waiting time is 13 days in warehouse H. Such as waiting time is considered normal since EOQ involves inventory carrying costs (Coyle, et al. 2003).

However, it was interesting to calculate the total C/T and the total L/T in the three processes to find out what is the proportion of value added time and non-value added time for the activities. The total C/T for the three activities amounts to 9.49 days and the total L/T amounts to 74.12 days (calculated from Appendices 5,6, & 7). In other words, the value added time is 9.49 days and the non-value added time is 74.12 days for the three processes. Figure 5-6 shows the value added and non-value added time expressed in percentage of the three processes.

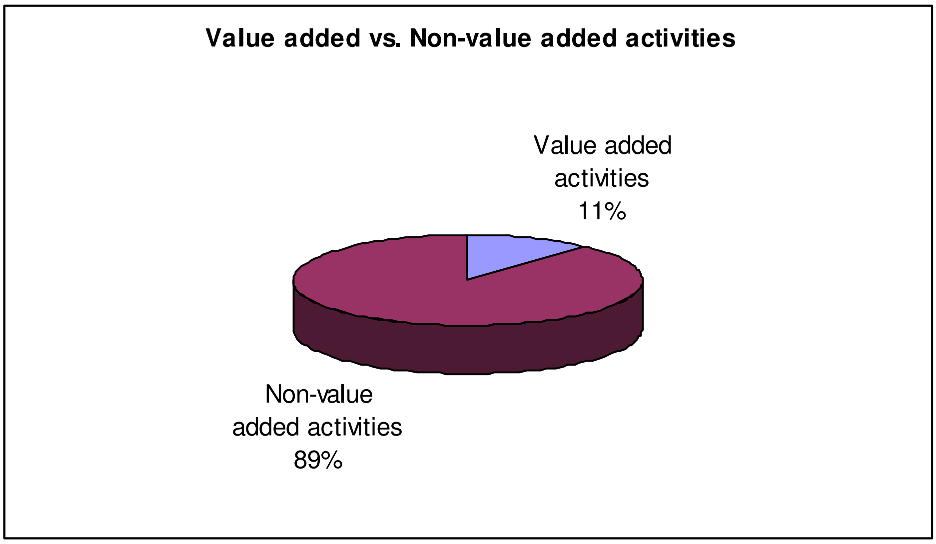


Figure 5- 6 Value added vs. non-value added time in the Value Stream Mapping

The value added activities amount to 11% and the non-value activities amount to 89%, see Figure 5-6. Thus, there are quite many resources spent to the non-value added activities, while only a small part of activities adds value to the products. The non-value added activities also involve the necessary but non-value added activities.

To summarize, the three processes of Origo flow show that there are some wastes in the flow of Origo components. In the next chapter we analyze the identified wastes. We limit the analysis of the processes to the mechanical workshop and warehouse H.

5.4 Identification and analysis of wastes in the flow of Origo

The current state map of the processes revealed some wastes in the flow of Origo. We identified the wastes of Origo flow by visualizing the CSM and analyzing the ToW. In the process of VSM the following empirical methods were applied: interviews with HAGS management, interviews with HAGS key partners, study of HAGS internal documentation and direct observations in the workshop and warehouse. As the result of application of the mentioned methodology, we were able to identify the following wastes: 1) waiting, 2) transportation, 3) unnecessary inventory, 4) unnecessary motion, and 5) defects. However, the managers at HAGS identified the wastes from 2 to 5, except 1, according to the ToW. The waste of waiting is seen from the current state map, whereas the waste of defects is initially revealed from the ToW.

We introduced the three types of activities in chapter 2.5.2. They are basically 1) Value-adding activities, 2) Necessary, but non-value adding activities, and 3) Non-value adding activities (Monden, 1993; cited in Hines & Rich, 1997). Womack and Jones (1996) referred that the second and third types of activities create "Type One *muda*" and respectively "Type Two *muda*". The objective of lean thinking organization is to remove the Type Two *muda*. We also use the same classification of waste in the discussion, i.e. Type One *muda* and Type Two *muda*. In the following chapters all the identified wastes will be analyzed.

5.4.1 Waiting

"The waste of waiting occurs when time is not being used effectively" (Hines & Rich, 1997, p.48).

Waiting in the order taking process

Waiting occurs when the customer places an order. It happens that raw material is not available in the stock. Then, the planner sends the order to the supplier and the workshop waits until the needed components are delivered. Actually, the operators "do not wait" and produce other components. However, we identified one week gap, see Figure 5-7, between the customer order entry and beginning of production in the workshop. There is one week order postponement, one week for the production, one week the painting operation and 2-3 days are taken for shipment to the customer. The final delivery time varies and it depends on the location of customer. Normally the lead time in the workshop is two weeks. Since it takes one week to deliver the requested raw material, the production in the workshop is delayed by one week either.

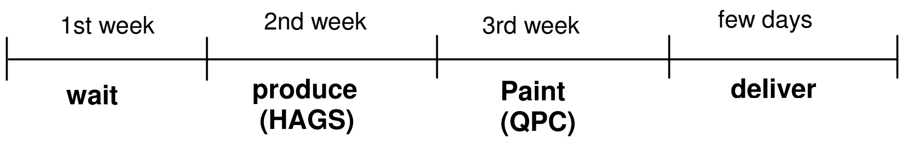


Figure 5- 7 The time frame of the order

The order time frame for the standard products is shown in Figure 5-7. In this figure HAGS is committed to deliver to a customer the product within three to four weeks.

Waiting in the mechanical workshop

Waiting in the mechanical workshop occurs due to the organizational structure of the mechanical workshop. There are three workshop managers who plan the production in the workshop. They plan and give orders what, when and by who to produce. It implies that either the components wait until the operator is free, or the operator waits until the components arrive.

In addition, we identified waiting during the process, i.e. work in process (WIP) by the observation and through studying the documentation of HAGS. The components wait in the work area from the moment when the operator starts the activity until he finishes the last component. The time lines of the processes in the current state map show the value added time spent on the operations and the total time spent on producing all the components. There is a high difference between the value added time (C/T) and the total time (L/T) required for the operations. The difference adds no value on the components to be produced and thus, can be reduced. The reason for that is the layout of the workshop is not proper. According to Srinivasan (2004), the *process layout* groups the workstations by operations, i.e. welding area, drilling area, cutting area, *etc*. The process layout hinders the continuous flow in the workshop. Thus, the components wait in the workstation until all of them are finished. Next, not all the workers are able to perform all the activities. It also implies the waiting time of the components. In addition, there are many components from other product families which have to be produced at the same time.

Waiting time associated with the painting activity to QPC

The waste of waiting occurs when the semi-finished components have to be sent to QPC for painting by transportation company LTN. LTN trucks come three times per week, according to the flexible schedule during the day, which suits more to them. As we calculated, the average of waiting time of components to be shipped to QPC is approximately 1 day, see Appendices 5-7. The reason is the trade off between costs of the provided services and the flexibility. If HAGS wants more flexible schedule it has to pay much higher price for the service.

The waste of waiting also exists at QPC. The components lead time at QPC is one week for the painting in standard colors. However, the total painting process is only approximately 270 minutes (4 ½ hours), see Appendices 5-7. This implies the waiting time of finished components before they are delivered back. According to QPC, the waiting time is "around 48 hours" until they are picked up by LTN for the delivery to HAGS. We calculated the waiting time as 5 working days * 6.7 net working hours – 4 ½ painting hours to equate 29 working hours at QPC.

Waiting in the warehouses

Waiting occurs in warehouse H at HAGS. The components wait approximately 2-3 weeks until they get a customer order. The final packed boxes wait other 2 days to be picked up by DHL or Schenker for transportation to the customer.

Sometimes the waste of waiting occurs during the stage of final packing. Some of the components are available in warehouse H for the final packing. However, some components are still missing, which have to be packed into the same box. The reason of components delay is one week waiting gap of raw material since the order is placed (see Figure 5-7). The other reason is the defects that occur during the production processes and/or the painting process. It delays the whole order fulfillment process by increasing the lead time of the products.

Waiting occurs in warehouse SV either. The raw material waits until it will be needed in the workshop. According to Supplier X requirement to purchase the minimum quantity of raw material, that is 10 tones, HAGS has an excess stock of raw material in warehouse SV. According to Srinivasan (2004), it is a policy constraint set by Supplier X. It is based on the economic order quantity (EOQ) and the changeover time of machinery. They calculated that it is not efficient to cut a low number of steel pipes, since the machine has to be adjusted according to the required length and diameter. Moreover, the policy of safety stock at HAGS implies that there is always some percentage of raw materials that waits to be produced. Thus, waiting time of raw materials in warehouse SV adds no value to the order fulfillment process, thereby constituting the Type Two *muda*, which has to be eliminated.

5.4.2 Transportation

"The waste of transporting involves goods being moved from one process to the next and adds no value" (Hines & Rich, 1997 p.48).

The transportation itself is considered as a waste, i.e. the Type Two *muda*. Figure 5-8 shows the transportation structure among the actors in the HAGS supply chain. The actors are involved in the order fulfillment process of Origo components.

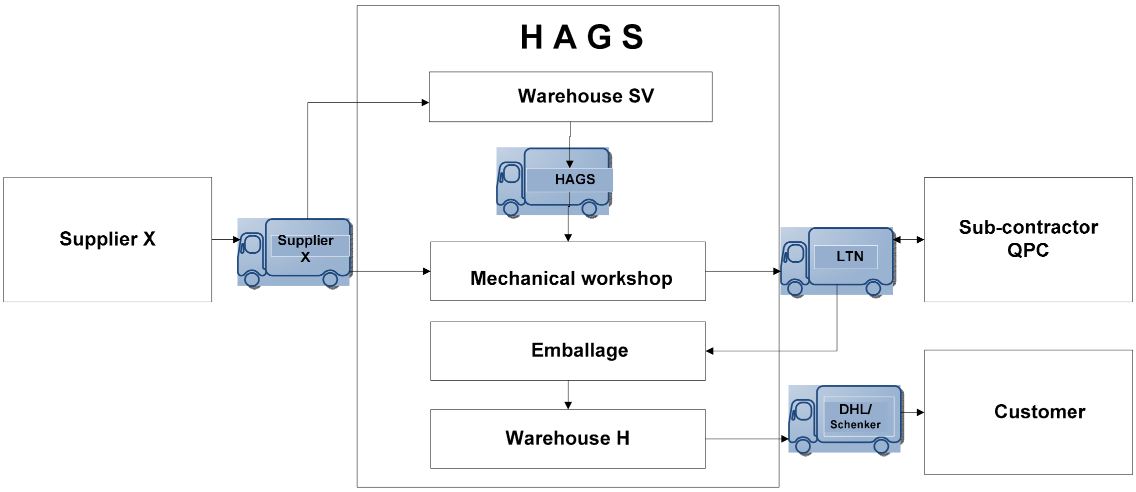


Figure 5- 8 The transportation structure

Supplier X ships the precut steel tubes either to warehouse SV or to the mechanical workshop at HAGS, see Figure 5-8, in order to support the production processes. One third of the input that feeds the production processes comes from warehouse SV and 2/3 directly from Supplier X. However, in the current state maps, Appendices 5-7, we assumed the input comes directly from Supplier X. It takes four hours and once per week to deliver the steel tubes from the central warehouse in the south of Sweden to HAGS industrial area. We consider warehouse SV as the extension of the HAGS industrial area despite the fact that it locates 2-3 km from HAGS main facilities. When the precut steel tubes are needed to feed the production they are delivered from the storage. The activity takes 1.5 days per week and is performed by a particular worker. The transportation link between Supplier X and HAGS we consider as being necessary, but non-value adding activity or the Type One *muda*. However, the transportation of raw material from warehouse SV to the mechanical workshop we consider as non-value added activity or the Type Two *muda* that can be eliminated.

Next, the transport links from the mechanical workshop to/from QPC painting company is in the both directions, i.e. the semi-finished components are shipped forward for the painting activity and backward to HAGS for packing. Inside HAGS industrial area the components are moved from the packing place to warehouse H by the own transportation, e.g. forklifts.

The transportation link between HAGS and its customers is performed by DHL and/or Schenker for the customers outside Sweden. LTN performs deliveries to the Swedish customers. The transportation company LTN is in charge to provide the shipment service three times per week. The delivery time and distance differs for each delivery and depends on location of customers. We identified the transportation link as necessary but non-value added activity or the Type One *muda*.

5.4.3 Unnecessary Inventory

"The waste of unnecessary inventory is a sign that flow has been disrupted, and that there are problems in the process" (Harrison & van Hoek, 2005 p.173).

Unnecessary inventory tends to increase the lead time, preventing rapid identification of problems and increasing space, thereby discouraging communication. In addition, unnecessary inventories create significant storage costs and, hence, lower the competitiveness of the organization or value stream wherein they exist (Hines & Rich, 1997).

The inventory of HAGS locates in three areas, such as warehouse SV, warehouse H and the mechanical workshop. We identified the unnecessary inventory respectively of raw material, of finished goods and work in process (WIP). We consider the unnecessary inventory as the Type Two *muda* or non-value added activity.

Unnecessary inventory of raw material

As we have mentioned before, the raw material comes from Supplier X and is stored in warehouse SV located 2-3-km from HAGS main production facilities. However, we consider it as the extension of HAGS industrial area.

The reason why HAGS stores raw material in warehouse SV is that Supplier X sets the minimum quantity to be purchased, that is approximately 10 tones. It can be treated as a policy constraint set by Supplier X. Supplier X created the requirement of machinery performance by never producing a batch of units below an economic order quantity (EOQ). The requirement is based on the changeover cost of machinery that is 100 SEK per machine. HAGS usually demands much less volume of the steel pipes. HAGS orders not only the steel pipes from Supplier X. Weekly demand also involves other types of raw material (Personal communication at HAGS, 2007-11-06). Thus, HAGS achieves the economy of scope and scale by ordering the full truck and few types of the raw material. However, it increases the inventory level because not all of the raw material will be directly used in the production.

Moreover, another reason for unnecessary inventory of raw material is the policy of safety stock level which is set by the GUDA information system. When the raw materials reach the buffer level GUDA system informs about the replenishment. In turn, the planners give the orders to respective suppliers for replenishment. The replenishment of raw material occurs even though HAGS has no customer order for that.

Unnecessary inventory of finished components

All the finished components are stored in warehouse H that locates in HAGS industrial area. We observed that there is a significant unnecessary inventory of finished components in warehouse H.

There are few reasons for the high number of finished components in warehouse H. First, according to the HAGS, the production is based upon both the annual production forecasting and the customer orders. The proportion varies accordingly to the low and high seasons (Personal communication at HAGS, 2007-11-22). Thus, we can state that the production policy during the low season is 'make-to-stock' and during the high season is 'make-to-order'. This implies that the production highly varies by seasons. The high season starts from the end of March until the end of October and respectively the low season is from November until April. For example, in periods of low seasons the production is driven more by forecasting than by customer orders and in high seasons, the situation is opposite. Thus, the production policy varies all the time and it depends on the customer orders.

Moreover, there is the capacity limits in the mechanical workshop during the high season. According to Srinivasan (2004), it is a physical constraint when the skilled operations are not available during the high season. This is one of the reasons why HAGS 'makes-to-stock' during the low season.

In addition, HAGS offers a high variety of products to its customers. The company launches new playing systems constantly. The high variety of products implies that HAGS produces a wide range of components to reach the buffer stock of every product.

Unnecessary inventory in the mechanical workshop

We observed the unnecessary inventory of components' flow between the processes and during the performed tasks, i.e. work in process (WIP). In addition, we identified the unnecessary inventory of WIP from the documentation provided from HAGS.

The identified reasons are the lack of cross-skilled operators, especially during high seasons. For example, in Origo production, during the process II rings are produced. "Only 6 welders out of 20 can perform the operation" (Personal communication, 2007-11-22). Another reason is that the workstations of the mechanical workshop grouped by operations, i.e. welding area, drilling area, cutting area, *etc*. Srinivasan (2004) refers it to the *process layout*.

5.4.4 Unnecessary Movement

"The waste of unnecessary movements involves the ergonomics of production where operators have to stretch, bend and pick up when these actions could be avoided" (Harrison & van Hoek, 2005, p. 173).

As we described in the frame of reference, the examples of the unnecessary motion are walking between processes, taking a stores requisition for signature or emptying parts from one container into another (Harrison & van Hoek, 2005). Such a waste is tiring for the employees and is likely to lead to poor productivity and, often, to quality problems (Hines & Rich, 1997).

Unnecessary motion in delivering the raw material

We found that the most often occurred the unnecessary movement of workers is the delivering the precut steel pipes from warehouse SV to the mechanical workshop. As we have mentioned before, Supplier X delivers the precut steel pipes either to warehouse SV or directly to the mechanical workshop. It depends on the quantity required for the production. When the raw material, stored in warehouse SV, is needed to feed the production, an assigned worker brings the requested material to the workshop. Warehouse SV locates not that far away from the main HAGS facilities, i.e. 2-3 kilometers, but still it takes time and workforce to bring the raw material to the workshop. HAGS counted that it takes 1,5 days per week. It implies extra costs for HAGS. HAGS recognize it as a waste of the Type One *muda*, i.e. activity is non-value added, but necessary. However, we consider the waste of Type Two *muda* because the worker could perform other tasks in the mechanical workshop instead of engaging in the activity that adds no value to the product.

Unnecessary movement in the mechanical workshop

Next, we identified the waste of unnecessary movement in the mechanical workshop. The work coordinator delivers the components to the next activity to workers who have finished their previous tasks or are finishing. It can be seen that the work coordinator activity implies as being non-value added but necessary, i.e. Type One *muda*. However, to take a closer look, it can be considered as Type Two *muda*. The waste of unnecessary movement of a worker attracts the waste of transportation. The reason for the wastes is the process layout, which implies unnecessary motion.

Unnecessary movement in the production process

In addition, we identified the waste of unnecessary movement of workers during the production process. Each working area is equipped with a set of tools. While the work in progress, the worker might need a tool to complete the task. It happens that the tool is missing and the worker need to find it or take it from the other working area. Moreover, sometimes it happens that "a tool is lying in the aisles between the working areas and no one knows to which working area it belongs to" (Personal communication at HAGS, 2007-11-22). This implies the Type Two *muda*.

Unnecessary movement in giving the production order

Moreover, we identified the waste of unnecessary movement of workers when the production order is to be delivered. The planning department plans the production, which is based on both the forecasting and the incoming customers' orders. The worker from the mechanical workshop comes and picks up the hard copies of production orders-tasks once a week. However, if they have urgent orders, the worker comes a few times per week.

Next, the detailed planning office in the mechanical workshop plans the production processes. There are three planning boards in the workshop where a detailed planner places the information about the work tasks. The detailed planner also checks if there are some preferences of work tasks. In case if yes, the tasks will be marked with the red stamp. The work coordinator has the responsibility to check the planning boards and to deliver the prioritized tasks to the production areas. The reason here is the centralized organizational structure in the workshop, where the orders are placed by the top managers. Thus, the identified is the Type One *muda*.

5.4.5 Defects

As we have mentioned in the frame of reference, the waste of defects implies that to produce defects costs time and money (Harrison & van Hoek, 2005). The Toyota philosophy tells that defects should be regarded as opportunities to improve rather than something to be traded off against what is ultimately poor management (Hines & Rich, 1997).

We identified the defects waste from Table of Waste, see Appendix 8, filled by HAGS management. It served us as a motivation to investigate the defects in the Origo flow starting from the mechanical workshop to the delivery to the customer, including the painting operation. All the identified defects are the Type Two *muda*..

Defects in the mechanical workshop

The large amount of defects occurs in the mechanical workshop. Many operations are performed with a touch of hand. For example, production Process II (production of the upper and lower rings) depends on the skills of the worker to high extent. The bending machine bends the steel pipes into the rings with the help of the special skilled worker. Only one welder manages the whole Process II, see Appendix 6, to reduce the defects. However, some defects still occur. Only six welders out of twenty can carry out Process II.

Moreover, the defects occur due to the galvanization of raw material. It protects the tubes from rust, but it makes the metal processing work much difficult. This implies the higher rate of defects in the mechanical workshop at HAGS (Personal communication at HAGS, 2007-11-06).

Defects at QPC

Next, the defects occur during the painting process at QPC. The painting process consists of the stage of preparation, such as components washing and hanging them on the hooks. The painting process is automated, except the hanging up components on the hooks. The components are painted in the painting room.

The defect rate of the painted components at QPC is around 10% (Interview with QPC, 2007-11-27). It is one of HAGS' concerns. According to HAGS, sometimes they receive the painted components from QPC with some defects. It happens that some of the components were not washed properly before painting process or were painted with infusion of dust, or the mark of hook is seen on the components. Then HAGS has to send them back to QPC for re-painting. It interrupts HAGS order fulfillment process by increasing the lead time and delaying delivery to the customers. HAGS expects high quality service from QPC, and improvement of QPC quality control (Personal communication at HAGS, 2007-11-06).

Errors of picking and final packing

Furthermore, the defects occur in the stage of order picking and final packing in warehouse H. We refer the errors of order picking and non-sufficient final packing as the defects. Since we were not able to follow the flow of Origo and identify the wastes during the picking and final packing, we identified the wastes during our personal communication with the logistics department (Personal communication at HAGS, 2007-11-22). The reclamation generates the large costs of getting the components back from the customers and sending the right ones. Reclamation due to damages in transit and picking errors amounts to approximately 5% per year (Personal communication at HAGS 2007-11-22). Component damages in transit occur due to non-sufficient final packing. The final packing means putting the components by the product names (for example, HAGS Agito has to be packed separately from UniMini or UniPlay playing systems) into one box. Due to non-sufficient packing some damages and scratches occur on the packed components while in transit. HAGS bears the expenses, which can be very high, especially when the customer locates far away from Sweden.

To sum up the identified wastes in the flow of Origo we provide Figure 5-9 where the reasons for wastes are shown.

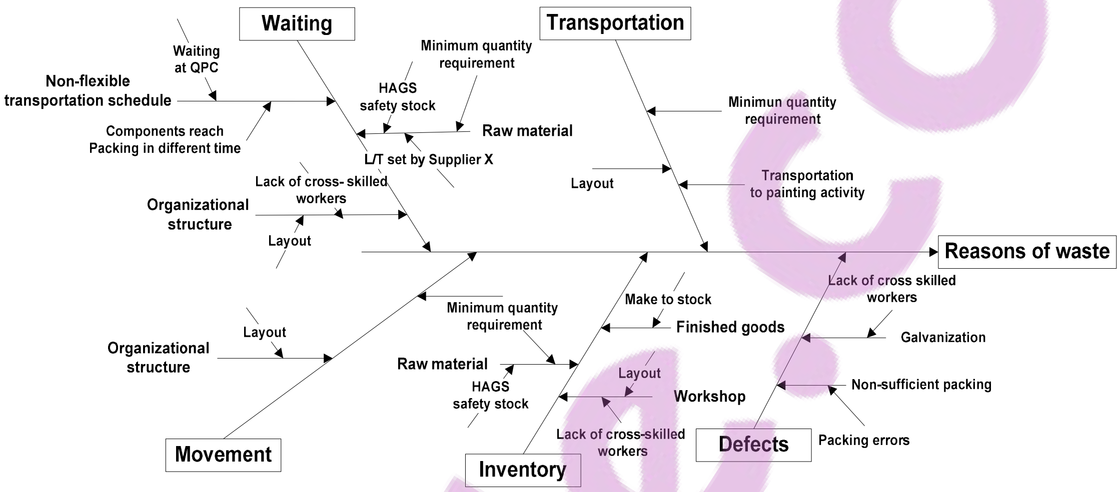


Figure 5- 9 The reasons of wastes of Origo value stream

As the result of the chapter, the most frequent reasons were such as the minimum quantity requirement set by Supplier X and improper layout that we found analyzing the waste of Origo flow. Both reasons were mentioned four times in the figure. They affect negatively waiting, transportation, unnecessary motion and inventory waste. Moreover, the minimum quantity requirement affects the safety stock of HAGS by increasing it. The lack of cross-skilled workers has effect upon defects, unnecessary inventory and waiting waste in the value stream of Origo. The existing centralized organizational structure contributes to the waste of waiting and movement. In addition, the organizational structure is connected closely with the reasons of layout and lack of cross-skilled workers. Thus, the waste has a synergy effect that one waste attracts other waste. The provided reasons can be applicable for other product families or individual product either.

5.5 Further analysis of the Current State Map

5.5.1 Postponement and Decision Point Analysis

As the combination of postponement theory and Decision Point Analysis we were able to determine what product delivery strategy was currently used by HAGS and where in the supply chain inventory was accumulated in terms of finished components.

We determined that HAGS uses the logistics postponement strategy, see Figure 2-6 in Chapter 2.8. The manufacturing activities are based on speculation, i.e. on forecasting, and logistics is based on postponement, i.e. on customer orders. Thus, the finished components are shipped from HAGS warehouse to the customer.

The Decision Point Analysis as an additional mapping tool helped us to determine the decoupling point in the HAGS supply chain. As we have mentioned earlier, the decoupling point is where the speculation strategy changes into the postponement strategy showing where there exists an excess inventory in a supply chain (Olhager, et.al., 2004).

The mapping tool is mostly used for "T" type of plants, which produce a wide combination of semi-finished products (Krishnamurthy & Yauch, 2007). We found out that HAGS matches the description. HAGS receives the precut steel pipes from Supplier X and the precut steel pipes leave the company in a wide range of components. The components are assembled at the customer place. By using the decision point analysis we determined the point where the value stream of Origo goes from push to pull system, i.e the point where the production based on forecasting switches to the production based on customer orders. The point is also called as the decoupling point (Olhager, et.al., 2004). The decoupling point maintains a level of safety stock. We have mentioned earlier, that the production in the mechanical workshop is based both on forecasting and on customer orders. The proportion varies during the high and low seasons of demands. HAGS bases the production on the yearly forecasts. However, the customer orders have the preference upon the planned production. Thus, we found that the decoupling point in the value stream of Origo in most cases is warehouse H, see Figure 5-10.

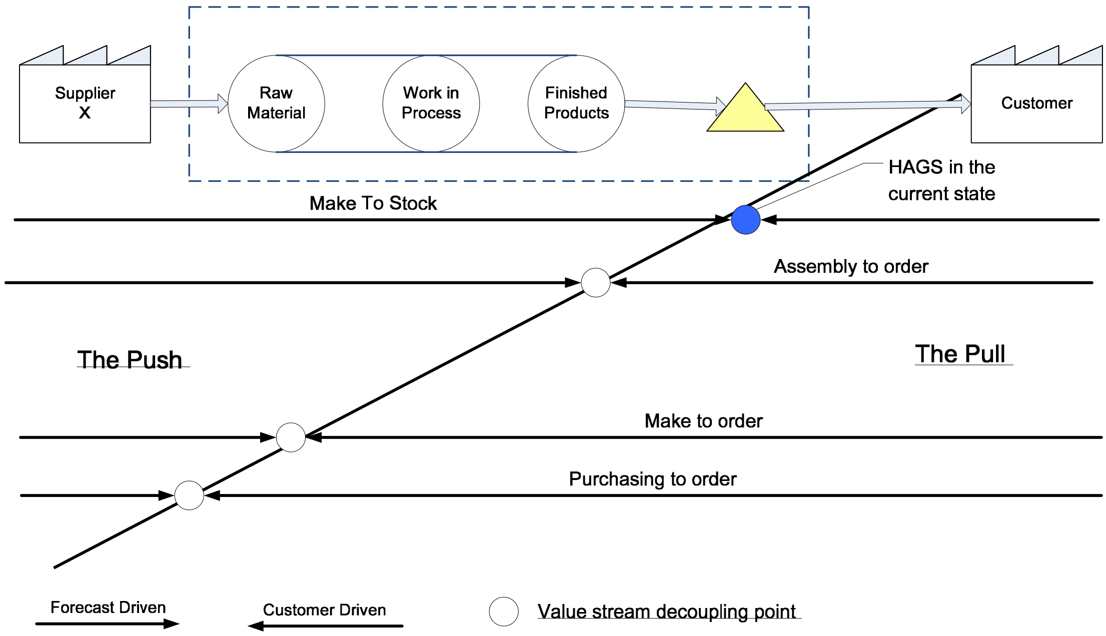


Figure 5- 10 The decoupling point of Origo value stream in the current situation (source: adapted from Hines & Rich, 1997)

Through the decoupling point it is possible to access the processes, which operate both downstream and upstream, in order to analyze where excess of inventory exist in value stream (Hines & Rich, 1997). The decoupling point is the moment when HAGS is ready to ship the order to the customer, see Figure 5-10. Thus, HAGS has high volume of unnecessary inventory which implies high costs. The unnecessary inventory has the synergy effect upon other waste such as unnecessary transportation, motion and defects.

The new Decoupling Point

We found that the decoupling point can be moved upstream in the supply chain of HAGS where the production would be pulled more on customer orders instead of focusing on the pushing system, see Figure 5-11. In other words, the production would be based more on 'make-to-order' instead of 'make-to-stock' principles. The advantage for HAGS would be less overproduction, unnecessary inventory and less waiting time of raw material. The reduction of the previous mentioned wastes has a synergy effect on other wastes such as unnecessary motion, transportation and defects, which would be reduced either.

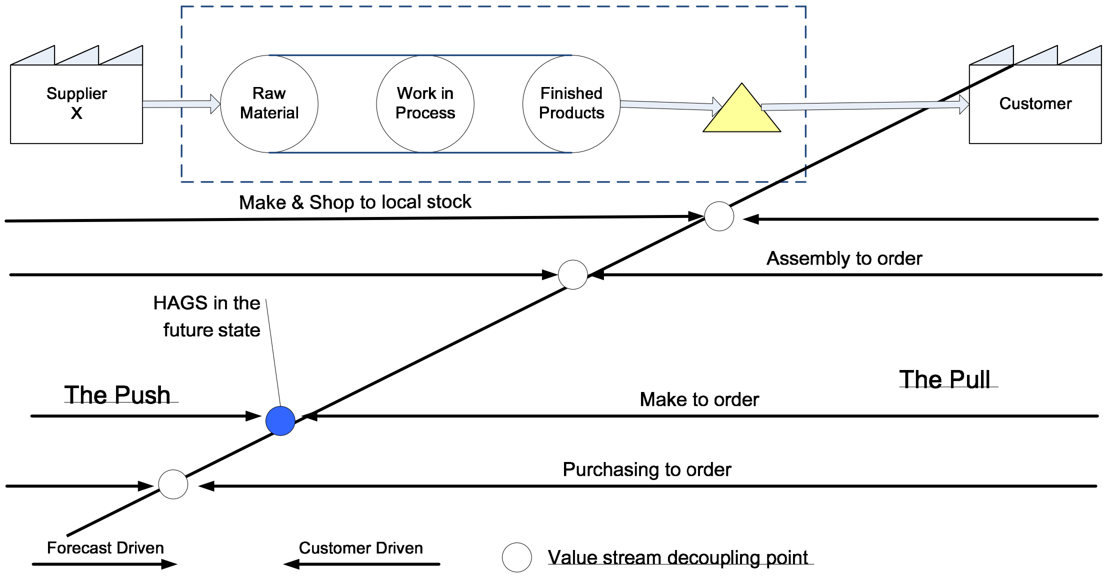


Figure 5- 11 The new decoupling point in value stream of HAGS (source: adapted from Hines & Rich, 1997)

However, it is a challenge to align the supply chain of HAGS according to the 'make-to-order' production strategy. The capacity of the production does not match the customer demand in the high season. Usually, during the high season of demand HAGS has many customer orders. It implies the waiting time of the components in the workshop. The solution is to establish the collaborative relationship with the key actors in the supply chain that HAGS could speed up the order fulfilment process.

5.5.2 HAGS positioning in terms of relationship

The relationships between HAGS and Supplier X started since 2004. According to the purchasing manager at HAGS, the company buys about 80% of the pre-cut steel tubes from Supplier X (Personal communication at HAGS, 2007-11-22). It amounts to 70% of annual sales of steel tubes of Supplier X (Interview with Supplier X, 2007-11-30). Thus, we can state that the HAGS is a very important customer of Supplier X, and in other hand, Supplier X is also the supplier of great importance. We introduced the supplier-buyer dependence grid in Figure 2-7 in Chapter 2.9. We applied the dependence grid to find out to what extent Supplier X and HAGS are dependent on each other, see Figure 5-12. The relationships between HAGS and Supplier X are dependent. It means the companies perform the supply chain approach, see Table 2-5. Regarding the positioning of HAGS in future we suggest that the company would stay in the same cell by going towards closer collaboration.

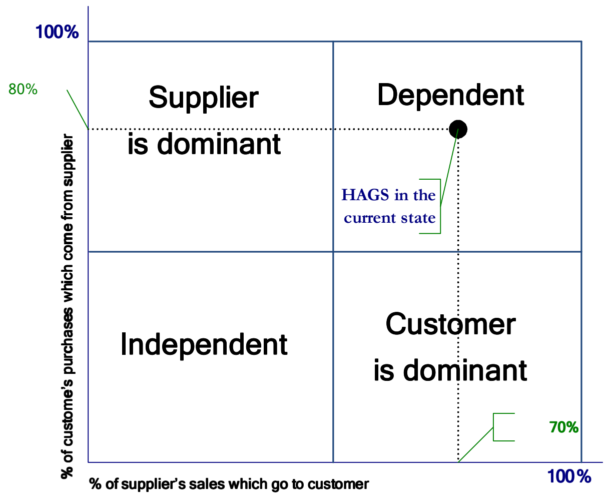


Figure 5- 12 HAGS and Supplier X dependence grid in the current state (source: adapted from Scott & Westbrook, 1991)

HAGS has to develop the closer relationships with Supplier X in order to get frequent deliveries of raw material, which would reduce the waste of waiting and inventory. Supplier X is not the sole supplier of the precut steel tubes. It implies that HAGS will not be dependent only on one supplier that gives the company some flexibility.

Next, the relationships between HAGS and QPC started since 2003. HAGS buys about 35% of the painting service from QPC. In turn, it amounts to 30% of annual sales of painting service of QPC (Interview with QPC, 2007-11-27). According to the dependence grid, the relationships between QPC and HAGS are independent, see Figure 5-13 a). It means the relationships are based on the traditional purchasing approach, see Table 2-5.

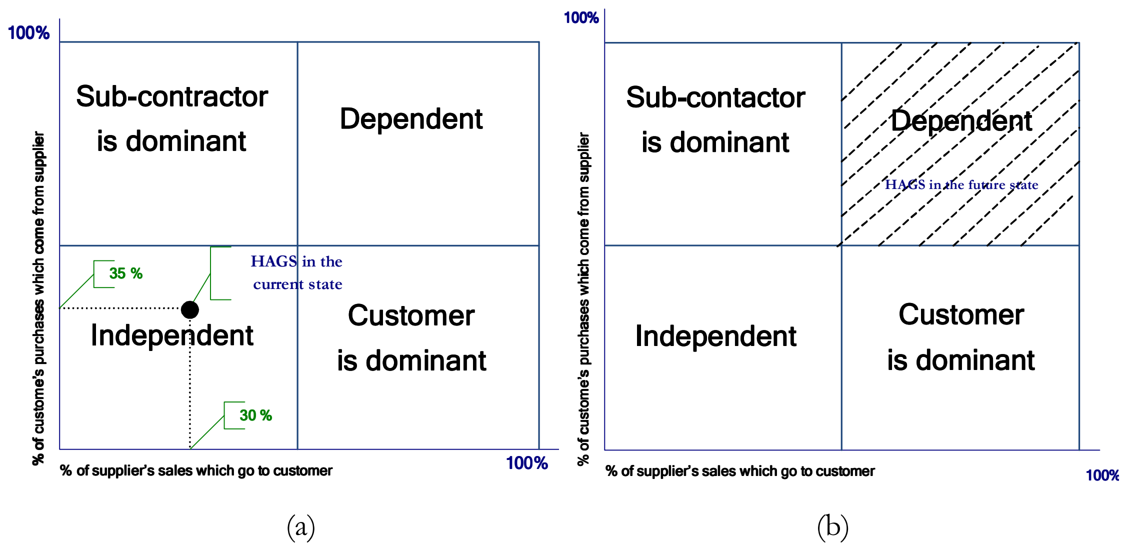


Figure 5- 13 HAGS and QPC dependence grid: a) the current state; b) the future state (source: adapted from Scott & Westbrook, 1991)

HAGS uses the painting service only for the metal components only, since wood painting is performed in-house. The positioning of HAGS in the future we suggest to move to the 'dependent' cell, see Figure 5-13 b). When HAGS goes towards the 'make-to-order' approach the company will need the frequent deliveries to/from the painting activity. The close collaboration with QPC reduces the waste of waiting and defects.

In addition, HAGS needs to get in closer collaborations with the transportation companies such as LTN, DHL and Schenker. We cannot provide the exact numbers of sales but we see the importance of the actors also. Especially, HAGS has to develop the closer relationships with LTN company since the components should be transported to QPC every day in a fixed time window.

To sum up, the supplier/buyer dependence grid method showed close collaboration with Supplier X and weak relationships with QPC. HAGS positioning in terms of relationship is to engage into the closer collaboration with the key actors in the supply chain. The relationships with Supplier X are already close. However, the relationships can be deepen to be able to perform the continuous flow of the components and move towards the 'make-to-order' approach. Next, the relationships with QPC can be deepen either by moving to the 'dependent' cell and exploring more supply chain approach. And finally, the close collaboration with the transportation companies helps to get more frequent deliveries.

5.6 Make Value Flow (II): Solutions to reduce the wastes and their influence

In this chapter we propose the ways to eliminate or reduce the identified waste in the flow of Origo product components. Then we propose a draft of the future state map as the result of the solutions to reduce the wastes and their influence on the business processes at HAGS.

5.6.1 Waiting

Waiting in the order taking process

At this stage HAGS has to negotiate with Supplier X in order to receive raw material more often. To engage in closer collaboration is important to lower the products' lead time, which starts from the stage of raw material and ends at the stage of finished product. Supplier X set one week lead time of raw material. Thus, it takes one week to produce the raw material and ship it to HAGS. However, we know that the total C/T of activities required to produce a product is much lower than the total L/T. Thus, we can assume that there is some waste in the business processes at Supplier X also. Through the closer collaboration with Supplier X it would be possible to balance the flow of raw material between the two companies that could be more responsive to the customer demand.

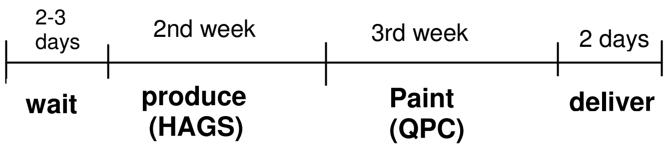


Figure 5- 14 The proposed time frame of order.

Waiting time can be reduced by order taking 2-3 times per week instead of one time per week, see Figure 5-14. According to Srinivasan (2004), it is the policy constraints when a company introduces the rules over the lead time of products. In the case, Supplier X sets a week's lead time of raw material. The policy constraints have to be exploited by the closer collaboration between Supplier X and HAGS to get deliveries more often, i.e. 2-3 times per week.

Waiting in the mechanical workshop

Organizational structure of the mechanical workshop has to be changed from centralized to decentralized. The detailed planning in the workshop can be changed into *kanban*. Kanban is the Japanese word that means a *sign* or *signal*. The idea of kanban is to "transfer production responsibility to the operators themselves rather than have a production controller decide in advance what each operator should be producing at a given time" (Srinivasan, 2004, p.171). Thus, the control of operations can be decentralized. The operator knows what to produce from the visual signal from the downstream. It means when the components are taken from the supermarkets for the final delivery, the kanban sends a signal to the planning department to start the production of the components. In the mechanical workshop, a withdrawal kanban can be used for replenishment of the components from a supermarket or warehouse. Moreover, a production kanban can be used to send a signal to the process operations to begin the production. Thus, the supermarkets will be also "useful where there are some obstacles in continuous flow due to cycle time variations between the processes" (Tapping & Shuker, 2003, p. 102).

The process layout in the mechanical workshop can be changed into a *cellular layout* (also called a *product layout*), which contributes to the continuous flow. Each cell consists of the operators and the workstations required to produce the components are arranged in the processing sequence. We suggest any of the configurations of the cell. We do not specify any particular cell configuration, since the workshop-managers would know better which configuration would suit best. The benefits of the cellular layout are WIP reduction, better space utilization, reduction in lead time, enhanced teamwork and communication, and better visibility of all tasks and operations (Srinivasan, 2004).

In addition, we suggest to cross-train operators. This would allow them to contribute to most operations in order to achieve the continuous flow in the workshop. For example, only 6 welders out of 20 can perform Process II. If HAGS gets an urgent order for any product, the operators will be able to switch to the operations that have high priority. The production will be possible to rebalance according to the preferences. It means that the larger number of cross-skilled workers can contribute to value stream. In turn, the production of other products will be slower since more operators are switched to the prioritized order.

Waiting time associated with the painting activity at QPC

The lead time associated with the painting activity can be reduced either. The cycle time of the painting process is 4 ½ hours. However, the lead time of components at QPC is a week, i.e. 5 working days. As the managing director mentioned, the finished components wait until they are transported about 2 working days. However, we think that the lead time can be shortened even more by closer collaboration with the sub-contractor QPC. QPC could reduce the lead time if they would investigate the activities from the moment when the components enter QPC until they leave. The identification and reduction of this waste improves the efficiency in the whole painting process. Thus, we see that the lead time can be reduced from a week to 2 days for the components to be painted in standard colors.

Waiting in warehouse H

The waste of waiting in warehouse H reduces if HAGS decides to change the production strategy from 'make-to-stock' to 'make-to-order'. The 'make-to-order' production strategy aids in the producing "only enough to satisfy the work requirements of the downstream customer" and to produce only when it is required (Tapping & Shuker, 2003, p. 47). The decoupling point moves upwards closer to the supplier, see Figure 5-11. It means that the production will be based more on the customer orders than on the forecasting. It implies that the waiting time in warehouse H will decrease same as the unnecessary inventory.

In addition, the waiting time could be reduced by closer collaboration with LTN transportation company due to better communication aiding in getting more flexible shipping schedules.

5.6.2 Transportation

The suggestion to reduce the waste of transportation is to "eliminate any temporary storage locations or stocking locations" (Tapping & Shuker, 2003, p. 48). In case of HAGS the suggestion will be to re-locate warehouse SV next to the mechanical workshop. It is important to re-locate warehouse SV closer to the workshop in order to "make the distance over which something is moved as short as possible" (Tapping & Shuker, 2003, p. 48). The "something" is the precut steel tubes that have to be transported as short as possible. Thereby, not only the waste of transportation would be reduced but also the waste of unnecessary motion.

5.6.3 Unnecessary Inventory

Unnecessary inventory of raw material

In order to reduce the volume of raw material from Supplier X we propose to develop the closer relationships with the supplier. Supplier X could introduce the smaller machines, which consume less electric power and have shorter changeover time. The smaller machines produce the precut steel pipes in small batches. It will lower EOQ, and in turn, the quantity of each order will decrease. It would be possible to ship the precut steel tubes not even more often but also in less volume. Thus, the quantity of unnecessary inventory in warehouse SV can be reduced by lowering the volume of each raw material delivery and increasing the frequency of raw material delivery from Supplier X.

Next, the safety stock at HAGS can be lowered when the production processes will be more efficient. To increase the efficiency in the workshop it would be possible by reducing the identified wastes and working towards the continuous flow, which increase the throughput of the machines.

Unnecessary inventory of finished components

The unnecessary inventory of finished components can be reduced when HAGS changes the policy of 'make-to-stock' to 'make-to-order'. It means to base the production more on the customer orders and less on the forecasting. The decoupling point will be moved from the stage where the finished components are in warehouse H to the stage where raw material is purchased, see Figure 5-11. It implies that the supplier has to ship the precut steel tubes more often compared to how it is done now, i.e. depending on the kanban signal.

Unnecessary inventory in the mechanical workshop

The unnecessary inventory, which is WIP, in the mechanical workshop can be reduced by working towards continuous flow. The standardization of work and workstations supports the continuous flow. The standard work has clear specifications and workers know how the tasks have to be performed.

5.6.4 Unnecessary Motion

Unnecessary motion in delivering the raw material

As we have described, the unnecessary motion of a worker occur when he delivers the precut steel tubes from warehouse SV to the mechanical workshop. It is the Type Two *muda*, which has to be eliminated, because the activity implies the costs only, expressed in 1.5 days of working time. Moreover, the leasing of warehouse SV also incurs costs. The suggestion is to re-locate the raw material storage from warehouse SV to adjacent to the workshop, i.e. the same suggestion as for reducing the unnecessary transportation. Thus, the precut steel tubes will be stored in the HAGS industrial area and it would eliminate the unnecessary motion of a worker and unnecessary transportation together.

Unnecessary movement in the mechanical workshop

The unnecessary movement in the mechanical workshop can be reduced by changing the layout of the mechanical workshop in order to eliminate the multiple trips. According to Womack and Jones (1996), the production areas have to be divided by product families. Currently, the components of Origo are produced in the different production areas in the workshop. After a production process is finished, the work coordinator picks up the components and delivers them to the next operation, which can be on the other side of the workshop. Having divided the production areas by product families the unnecessary movement of the work coordinator and transportation inside the workshop would be reduced. However, it is not easy task to do that taking in the consideration that there exists "unspecified number of product families in the mechanical workshop" (Personal communication at HAGS, 2007-12-10). Thus, by dividing the production areas all the product families have to be taken into consideration.

Unnecessary movement in the production process

We identified the unnecessary movement of workers in their working areas. As we have mentioned, each working area is equipped with a set of tools required to produce an operation. The unnecessary movement of a worker is when a worker has to search after the tool needed to perform an operation.

There is a need to standardize workstations and arrange them in the way that a worker can easy find what he needs to perform an operation. The suggestion will be to introduce the 5S system. "5S is an improvement process, originally summarized by five Japanese words beginning with S, to create a workplace that will meet the criteria of visual control and lean"(Tapping & Shuker, 2003, p.88). By implementing 5S, it would be possible to organize and standardize the workplace and reduce the waste.

To begin with we propose to perform the first three standards of 5S system. The tools have to be sorted out and the unnecessary tools have to be removed. The necessary tools have to be placed in the easy accessible place. Moreover, each tool has to be marked that it will be seen to which working area it belongs to. In future, the last two steps have to be performed too, because not performing e.g. the fifth step, might hinder "maintaining orderliness and practicing the first four S's continually" (Srinivasan, 2004, p. 153).

5.6.5 Defects

Defects in the mechanical workshop

For the work activities that highly depend on the skilled workforce the rate of the defects tend to be much higher than for the standard work activities. Since the defects occur mainly due to the human errors, we suggest employing the modern bending machine, which could facilitate the work and reduce the rate of defects.

Defects at QPC

We have mentioned earlier that the defect rate of the painted components at QPC is around 10% (Interview with QPC, 2007-11-27). It is nothing new that defects occur time to time. The main issue at this point is that the defects have to be corrected in due time. The delays of the defected components, which have to be fixed, negatively affect the order fulfillment process of HAGS. The suggestion is to improve the communication between HAGS and QPC. By improving the communication we mean the closer collaboration with QPC. QPC has to tell about the problems immediate, which occur during the painting process. This would help HAGS to fulfill the customer orders on time.

Errors of picking and final packing

As we stated earlier, the reclamation generates large costs of getting the components back from the customers and sending the right ones. It is the Type Two *muda*, i.e. non-value added activity, which has to be eliminated.

We suggest to introduce the principle of double checking of orders picking. It means that two workers will be involved in the order picking process. One of them picks the components from the shelves according to the picking list and brings them to the final packing area. The other worker would do the final packing by re-checking the components from the list of order picking. The errors of picking and final packing will be decreased by double checking. It would not slower the working process, because the first worker will continue to pick the next order.

Next, the application of 5S System discussed in Chapter 2.2, helps to facilitate the picking process in the warehouse. We suggest sticking the barcode in a visible way. The problem is that some components are small or thin and the barcodes are wrapped on the components. It is difficult to see the barcode and it makes the order picking process slower. We suggest to introduce the hard plastic cards. The barcodes can be stuck on a hard plastic card and then the card can be attached to the small and/or thin components. It will facilitate and make faster the order picking process because the barcode will be visible.

In addition, to facilitate the order picking process we suggest to do the pre-packing of the products according to their standard variations. For example, Origo family components are in the heart of the whole HAGS Agito playing system, see Appendix 9. Origo is a standard product with almost no variation. The only variation is that the coupling bows can be two, instead of one. Thus, the family of Origo components can be pre-packed in advance and the information about the components inside has to be written on the box. It will speed up the order picking process and reduce the probability of the errors due to the fact that the pre-packing would be performed when there are no general orders to perform.

To summarize and visualize the solutions to reduce influence of waste we condensate them in Figure 5-15.

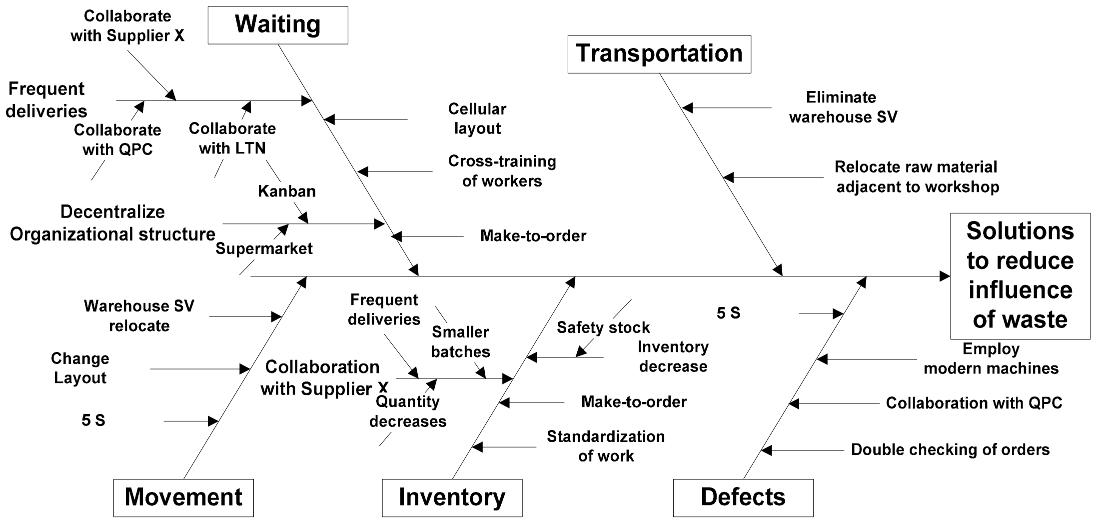


Figure 5- 15 The solutions to reduce the wastes in the Origo value stream

Since the most frequent waste was the requirement of minimum quantity to be purchased from Supplier X, see Figure 5.9, we highlighted the importance of collaboration with Supplier X, sub-contractor QPC and transportation companies LTN, DHL and Schenker. If HAGS wants to lean the value stream of its products the company has to think beyond the boundaries. The managers have to collaborate with the actors in the supply chain to get win-win situation. To work towards the continuous flow in the mechanical workshop the suggestions were to introduce the 5S system, to change the layout from the process to the cellular and to enable cross-training of workers. Only when HAGS will lean the value stream flow within its workshops then the decoupling point can be switched upstream by performing 'make-to-order' strategy. It will be able to base the production more on customer orders and less on forecasting.

5.7 Draft of Future state map

Having identified the wastes and associated problems by means of the current state map, some of the necessary changes in the value stream of Origo were outlined in the draft of the future state map, as shown in Figure 5-16.

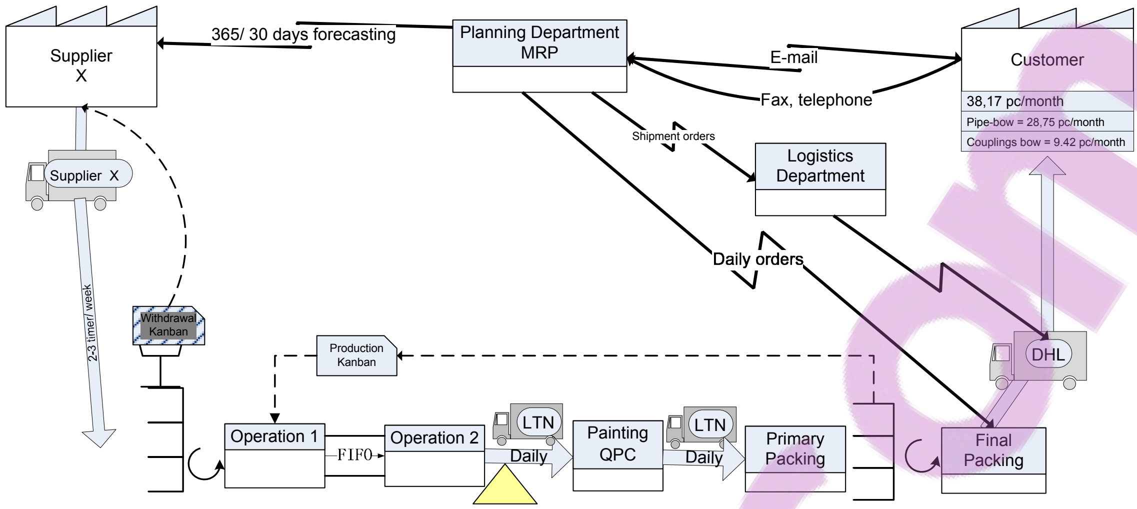


Figure 5- 16 A draft of the future state map for value stream of Origo (for a larger version see Appendix 10)

We propose to work towards the 'make-to-order' production strategy as shown in Figure 5-11. HAGS has to work towards the continuous flow in all the workshops, including the mechanical, wooden and carpentry in order to be able to explore the 'make-to-order' strategy. The principles of Supermarket, Kanban and FIFO (First In First Out) aid in achieving the continuous flow in the workshops and 'make-to-order' production strategy, see Figure 5-16 and Appendix 10. In the future state map draft we show only the principle how the order fulfillment process could work. The reason is that set the limitation of analyzing the first three lean principles and in turn, omitting the last two principles. The forth lean principle – pull scheduling – deals with implementation of FSM that is out of our scope. That is why we do not show the three processes and their timeline through the operations.

In the beginning of the value stream flow the supermarket is used to build the safety stock level. The shelves in the mechanical workshop and a warehouse next to the workshop fulfill the role of the supermarket. Another supermarket will be introduced at the end of the value stream flow, i.e. in warehouse H, before the final packing activity.

During the entire production process, Kanban is proposed to be used to give information and control the flow. There are two types of Kanbans to be introduced: a withdrawal Kanban and a production Kanban. When HAGS receives a customer order, the planning department sends the specification of order to the final packing. The components will be taken from the supermarket and packed. When the components are withdrawn from the supermarket, the kanban gives a signal to the first production process. Then, the raw material is taken from the first supermarket. As soon as raw material is withdrawn from the first supermarket, kanban gives a signal to Supplier X when raw material has to be replenished. The result is that Supplier X will replenish raw material more often, for example 2-3 times per week. The information exchange between HAGS and Supplier X is still based upon orders and forecasting. GUDA system will be no longer at the center of HAGS, but it will be used for annual and monthly forecasting.

FIFO in between the operations means that WIP inventory will be reduced. As soon as a component is finished it will be moved to the next worker who does the next operation. The concept of one-piece flow means that one unit of product moves at a time between workstations, rather then processing an entire batch at the workstation (Srinivasan, 2004).

Thus, FIFO enables to shorten lead times and aids in the continuous flow of the components through the processes.

The benefit here will be that HAGS will be able to remove the unnecessary inventory until the safety stock level and warehouse SV will be eliminated since the safety stock of raw material can be stored in the HAGS industrial area. Moreover, the benefits from eliminating warehouse SV are saved costs in terms of unnecessary transportation, human labor and renting costs, which add no value to the products.

Next, we suggest that the components should be taken for the painting operation every day within the fixed time window. HAGS and LTN should agree upon the time schedule that would suits to both companies. If the components are taken form HAGS every day within the fixed time window, the average waiting time for the semi-finished components will be reduced to 0.5 day instead of 1 day.

Moreover, we suggest reducing the role of the purchasing department. The planning department can carry out the daily orders through EDI. There is a need to introduce 5S system for the components. The components could have smart tags, e.g. the color codes or other agreed signs. Each color and other signs have a meaning in terms of orders. For example, the components marked with blue color have to go through all operations accordingly to the steel pipes. Even QPC has to be integrated into the system. Workers at QPC have to understand the information in the code about the specification of order, i.e. what color the components have to be painted. If the components are small, then the box should have the same code also. The advantage is that it will be no paper work in the planning department anymore. Next, the purchasing department could give up making orders to QPC, because the codes represent the orders. In addition, the role of the detailed planning in the mechanical workshop could be reduced through employing the kanban and supermarket principles. The employees should be switched to other activities.

5.7.1 Summary of changes introduced in the future state value stream

HAGS is recommended to re-organize the production workshop in order to be able to move towards 'make-to-order' principles, which aid to remove many wastes in the organization and the value stream flow. It helps to enhance the efficiency and throughput of the machinery in the workshop. The company could be engaged with continuous improvement of the components flow.

We condensate the proposed changes in the draft of the future state map, as follows:

- Functional changes were proposed in terms of changing layout, introducing 5S principles and FIFO components flow.
- Production principle was proposed in terms of 'make-to-order' strategy.
- Production control and information changes were suggested by introducing kanban.
- Reduce the role of the purchasing department in order making to QPC by introducing the smart tags.
- Detailed planning in the mechanical workshop it might be avoided: both the planning department and kaban system performs planning and control functions.

- 5S system could be introduced to reduce the paper orders and facilitate the flow of components, and picking and packing activities.

- Warehouse SV would not be needed since Supplier X delivers raw material frequently and in smaller quantities. Supplier X would deliver raw material according to the kanban signal, say 2-3 times per week.

- LTN should pick the components to the painting operation every day within the fixed time window.

5.7.2 The benefits of the new components flow

Below we summarize the benefits of the new components flow as compared to the existing components flow:

- The unnecessary inventory will be reduced to the safety stock level through
    - The production based on customer orders rather than on forecasting as it was before.
    - Frequent deliveries due to closer collaboration with Supplier X, subcontractor QPC and the transportation companies.

- The following costs associated with the delivering raw material from warehouse SV will be saved:
    - Transportation,
    - Human Labor,
    - Warehouse renting costs,
    - Unnecessary inventory.

- The order fulfillment process will be faster due to the total C/T and total L/T of all the three processes will decrease through
    - The cellular or product layout
    - FIFO – aids in continuous flow and reduction of WIP
    - 5S System to facilitate the communication between HAGS and QPC, and aid in smoother flow of the components starting from the production processes and ending by the picking & packing activities in warehouse.

- The visibility and control of raw material and the components that move along the production processes will improve due to Kanban signaling system and supermarkets.

6 Conclusions

The purpose of this chapter is to summarize the research in three perspectives, as the conclusion of this thesis.

6.1 Methodological implication

The lean thinking framework with the focus on the principle of making value flow was applied in this thesis in order to visualize the current state map, and identify and reduce the wastes in the Origo product flow at company HAGS. Within this framework, a combination of the theoretical and empirical approaches was proposed.

The theoretical part was mainly represented by the value stream mapping method. Furthermore, other methods like the decision point analysis as an additional "gap filling" mapping tool, the postponement theory, and the supplier/buyer dependence grid were subsequently applied to analyze HAGS relationships with key business partners.

The empirical part of the presented methodology included interviews both with HAGS management and with HAGS' sub-contractors and suppliers. The interviews were used within the lean thinking framework for specifying value and identifying the value stream. Additionally, field observations including visits to workshop and warehouse were conducted, where machine cycle time measurements and checking available Origo components were respectively performed. However, due to time constraints, the cycle time measurements were performed only for some of the Origo components and the production defects were not observed. The information about the defects was obtained from the Table of Waste that was applied as an additional empirical tool along with the value stream mapping method for visualizing the current state map for Origo components value stream.

The current state map was then analyzed to identify, and find reasons for the wastes in the existing Origo components value stream.

At the final phase of the study, the modifications were proposed in the current Origo flow, in order to reduce the most critical wastes. It was achieved as the result of deeper investigation of both the decoupling points (decision point analysis and the postponement theory) and the HAGS collaboration with the key actors in the value stream (supplier/buyer dependence grid method). The decision point analysis together with the postponement theory helped to determine the current product delivery strategy and find out where the products' flow in the value stream went from push system to pull system, whereas applying supplier/buyer dependence grid method revealed the need of improvement of HAGS relationships with key partners, Supplier X and QPC.

The proposed modifications were then visualized in the draft of the future state map for the Origo components flow at company HAGS. It is however necessary to mention the limitations for practical application of the obtained results. Being methodologically important, the performed single-product family flow analysis has to be extended to processes and activities connected to other product families in order to balance all the product flows and form the complete picture of the existing waste-related problems. In spite of the mentioned limitations the presented methodology could in future be used at HAGS as a pilot tool for value stream analysis of other product families. Furthermore, the case study methodology is believed to be of use for other companies having similar profile and dealing with similar problems in their product flow.

6.2 Theoretical conclusions

The theoretical part in the presented research methodology consisted of the value stream mapping method, decision point analysis, the supplier/buyer dependence grid method. All the methods are combined within the lean thinking framework. In general, the principles of the lean thinking include: 1. specify value, 2. identify value stream, 3. make value flow, 4. pull scheduling, and 5. seek perfection. In the presented work the focus was placed on third principle, and the first two principles were addressed briefly in order to prepare necessary information for making the value flow. Principles 4 and 5 were not considered since the implementation phase of the value stream is out of scope of the presented study. The lean thinking framework was found useful to simplify the conducted analysis and make it systematic, also enabling consideration of other products and their associated wastes in future analyses.

The value stream mapping method was applied to construct a general picture of value stream including the supplier and sub-contractors in order to find the weak points in the value stream. It can be concluded that additional tools, both empirical and theoretical are needed for identification of some wastes (e.g. defects) and for more deep investigation of some wastes (e.g. excess inventory). Particularly, the Table of Waste was applied as additional empirical tool to assist in waste identification. Furthermore, the decision point analysis together with postponement theory (for the excess inventory) and the supplier/buyer dependence grid were applied as additional analytical tools both to investigate the value stream and to reduce the wastes. As the result of application of Decision Point Analysis and the postponement theory the decoupling point was found in a warehouse at HAGS. On the other hand the supplier/buyer dependence grid method showed close collaboration with Supplier X and weak relationships with QPC. The supplier/buyer method helped us to see the supply chain of HAGS from the wider perspective. We found the application of the method relevant since the company had to take into account the relationships with the key actors when reducing or eliminating wastes within and beyond the company.

It was thus concluded that the value stream mapping method can efficiently be used only along with the additional mapping and other analytical tools supplying a more detailed picture of the current product value stream, considering the specific nature of company processes and business partners.

6.3 Managerial implication

Comprehensive study of the Origo components flow resulted in visualization of the current state map and identification of the most important wastes: waiting, transportation, unnecessary inventory, unnecessary motion and defects.

Two most common reasons were found for the wastes. The first reason was the requirement of minimum quantity of raw material to be purchased from the supplier, contributing to the wastes of waiting, transportation, unnecessary motion and inventory. The second reason was the improper workshop layout that contributed to all five identified wastes, including the defects. Reducing of the identified wastes would lead to managerial consequences for HAGS.

First of all, relations with suppliers and sub-contractors could be modified by better integrating the key actors into the HAGS' supply chain. It is worth noting that all the supply chain actors, including HAGS, would benefit from it in terms of waste reduction for inventory, motion, and waiting. Such a close relation between HAGS and the key actors can efficiently be realized within the Kanban signaling system. In this case, however, transportation schedule and costs might require additional analysis and optimization.

Secondly, the workshop layout at HAGS is currently represented by the process layout divided by operations. It is proposed to adopt the cellular or product layout. This would result in reduction of transportation within HAGS, unnecessary motion, defects and WIP inventory. Introduction of the Kanban signaling system would also infer changes in the workshop organizational structure, making it decentralized, e.g. by reducing the role of the detailed planning division.

Next, the decoupling point (currently located in a HAGS warehouse) could be moved upstream and production has to be based rather more on customer orders than on forecasting, mainly for inventory reasons and for speeding up the order fulfillment process.

The mentioned measures to reduce wastes were summarized in the draft of the future state map. The main advantages of the proposed future state are faster order fulfillment process, gained visibility and control of raw material and reduced costs. The presented draft of the future state map is believed to be useful to HAGS as a starting point for improving efficiency of their product flow.

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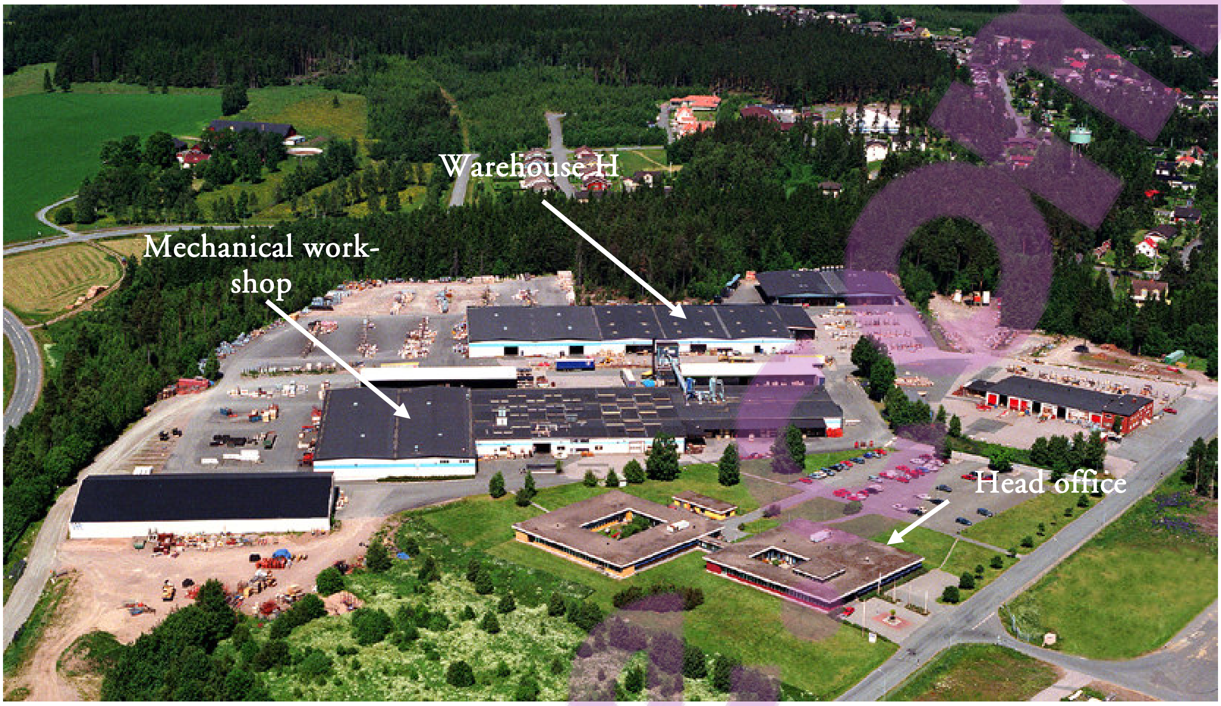
Appendix 1 – HAGS Manufacturing Facilities and Head Office in Aneby



Source: HAGS presentation

Appendix 2 – Interview guide

The following questions are guidelines for our interviews throughout this research. Note that this guide gives us an outline about our area of interest. However, we ask not only the below shown questions.

Manufacturing

- What problems do the company experience producing the components?
- How many people work in the mechanical workshop?
- What is the lead time of components in the mechanical workshop?
- Do you perceive the manufacturing is efficient?
- Do you have all needed components for production of the chosen product?
- If not, then how long is the outage?
- What are the working hours at the mechanical workshop?
- Is work automated or manual?
- Who owns the components in stock?
- How big is the inventory stock? (i n days)

Warehousing

- Who owns the warehouse you are using?
- How is the warehouse organized? *We shall use observation here*
- Do you have other warehouses? If yes, where?
- How Origo components are stored? Assembled or preassembled?
- What is the pack size, i.e. the number of items in a shipment?

Designing the supply chain

- Who are your suppliers? Where are they located?
- Who are your customers? Where are they located?
- What are the types of the customers?
- What are the largest customers?
- How many customers (approx. per year)?
- Are there other actors involved in the HAGS supply chain?

Value Stream Effectiveness

- Do you always have the raw material available for the production?
- Do you always have the components needed in desired quantities?
- What is the percentage between the components need to be produced and the components available when you receive an order?

Customer service

- Do you help your customers to choose a playground?
- Do you provide your customers with any information how they have to look after the equipment?

Appendix 3 – Interview questions

Interview introduction

We are two students from Jönköping International Business School studying the program of International Logistics and Supply Chain Management. Currently we are writing the master thesis at HAGS Aneby AB.

We were asked to investigate the flow of Origo components in the mechanical workshop at HAGS in order to visualize the components' flow throughout the production processes. To investigate the flow we map the production processes in the mechanical workshop. In order to achieve this, we need to interview employees of different departments inside the company and external companies which have close connections in the order fulfillment process.

Purchasing Department

- What is the base of suppliers?
- How many suppliers HAGS considers as the most important?
- What were the criteria of choosing the most important suppliers?
- What is the minimum quantity of the raw material is to be purchased at once?
- What is the lead time of components to QPC?
- Do all the companies involved in the order fulfillment process perform their tasks without delays?

Planning Department

- What kind of planning system does HAGS use?
- What are the customer requirements per month, i.e. how many Origo family components do customers require on the monthly base?
- In what way and how often customers do send orders?
- How often the production planning department sends the production plans to the mechanical workshop?
- What is the annual production volume of each component of Origo?
- What is the current lead time of the Origo components throughout the production processes, i.e. from the stage of raw material to the finished product?

Production Department

- What kind of production control system does HAGS use?
- What are the main production activities that need to produce the Origo family components?
- What is the number of product variations in the Origo production?
- How many parallel value streams flowing into one do involve into the flow of Origo components?

Mechanical Workshop

- What is the number of operations needed to produce the Origo?
- What is the number of people working in the process?
- What is the quantity of work performed in one day by one person?
- What is the frequency of work that is delivered to the next process?
- Do people work in shifts?
- What is the total time per workday?

Warehousing

- Who owns the warehouse you are using?
- How is the warehouse organized? *We shall use observation here*
- Do you have other warehouses? If yes, where?
- How Origo components are stored? Assembled or preassembled?
- What is the pack size, i.e. the number of items in a shipment?

Customer Service

- How many customers do HAGS has per year?
- What are the types of customers?
- What is the largest of customer?
- How orders reach HAGS? Via e-mail, fax, telephone.

Supplier X

- What is the number of employees?
- What part of the total volume of raw materials is sold to HAGS? (in percentage)
- What are the ownership relations for raw material when it passes throughout the supply chain?
- How long has Supplier X been HAGS' supplier?
- What is the lead time you promise HAGS for each order? What is the operation time for each order (processing time)?
- How long does it take to ship the order to HAGS? (in distance, in hours and minutes)
- What will be your expectation concerning about the collaboration, communication, transportation and *etc.* between Supplier X and Hags?

Quality Powder Coating AB

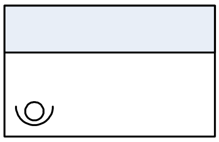
- What is the number of employees?
- What is the turnover of QPC?
- What part of the total volume of surface treatment service is sold to HAGS? (in percentage)
- Do you consider HAGS Aneby AB as an important customer of yours?

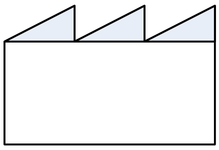
- How long is the painting process?
- How long the components stay at QPC? (the lead time of painting)
- How long do the finished components wait until they are delivered to HAGS?
- What is the painting defect rate?

LTN

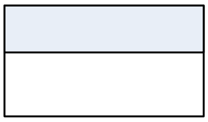
- What is the number of employees?
- What is turnover?
- What is your specialization (core competence)?
- What part of the total volume of transportation service is sold to HAGS? (in percentage)
- How often does LTN pick up the trailer for the shipment it to QPC?
- Does LTN pick up the trailer at the fixed time? If no, why?
- Do you think would be it possible to have the fixed pick up times?
    - If yes, what can be the condition HAGS has to achieve?
    - If no, what are the reasons behind it?
- Do you consider HAGS Aneby AB as an important customer of yours? Why?

Appendix 4 - Icons


Process table

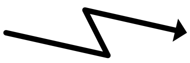

Customer / Supplier / Sub-supplier

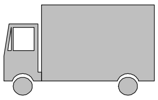

Data table


Production control

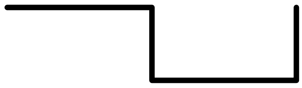

Shipment arrow

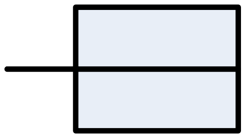

Manual information

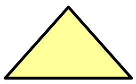

Electronic information

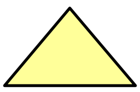

Shipment truck


Information system

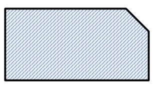

Timeline segment

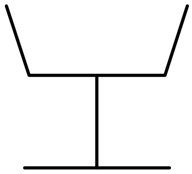

Timeline total


Inventory

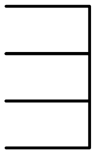

WIP

Work in process

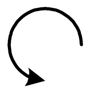

Withdrawal kanban


Kanban post


Production kanban

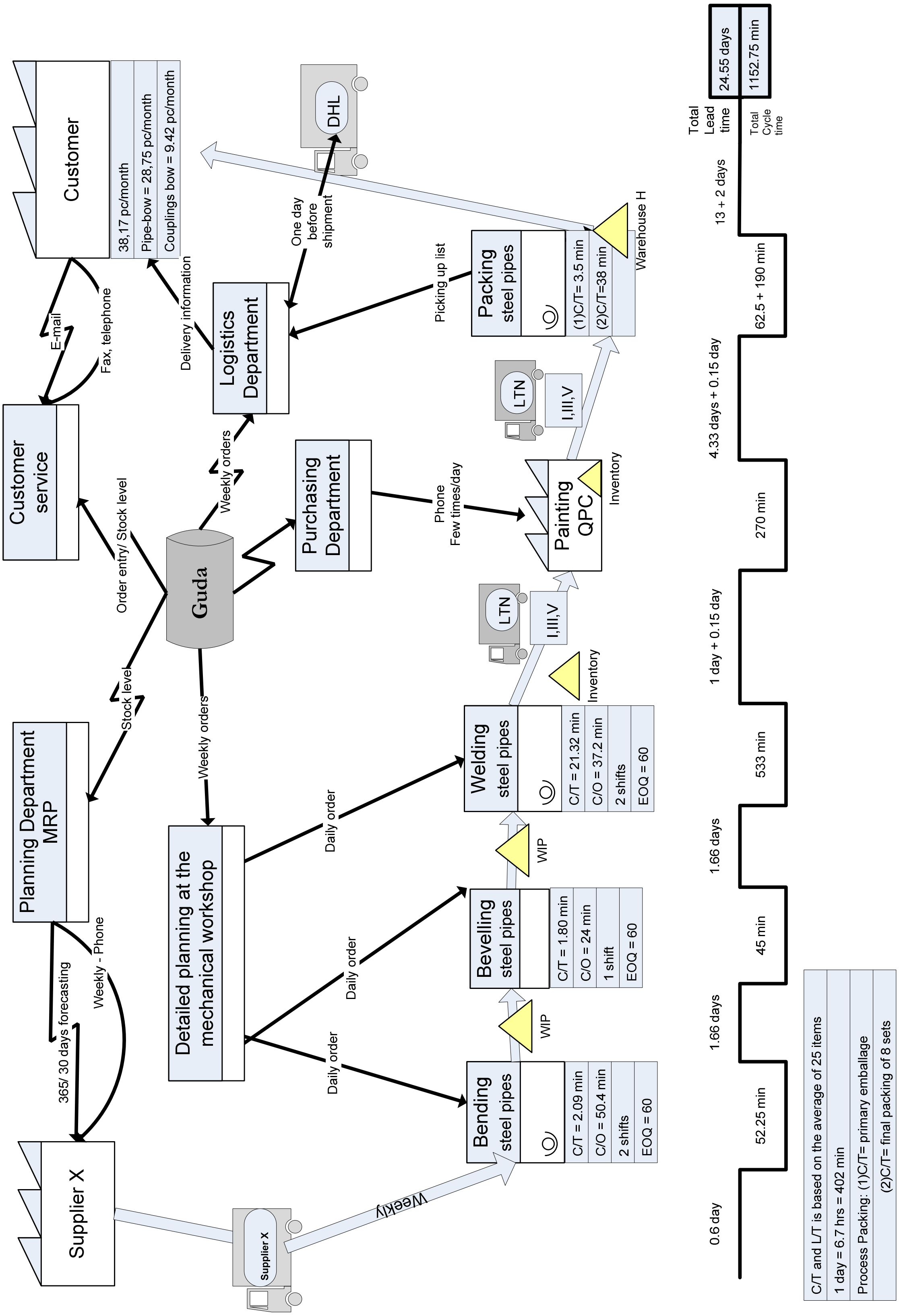

Supermarket

First in First out

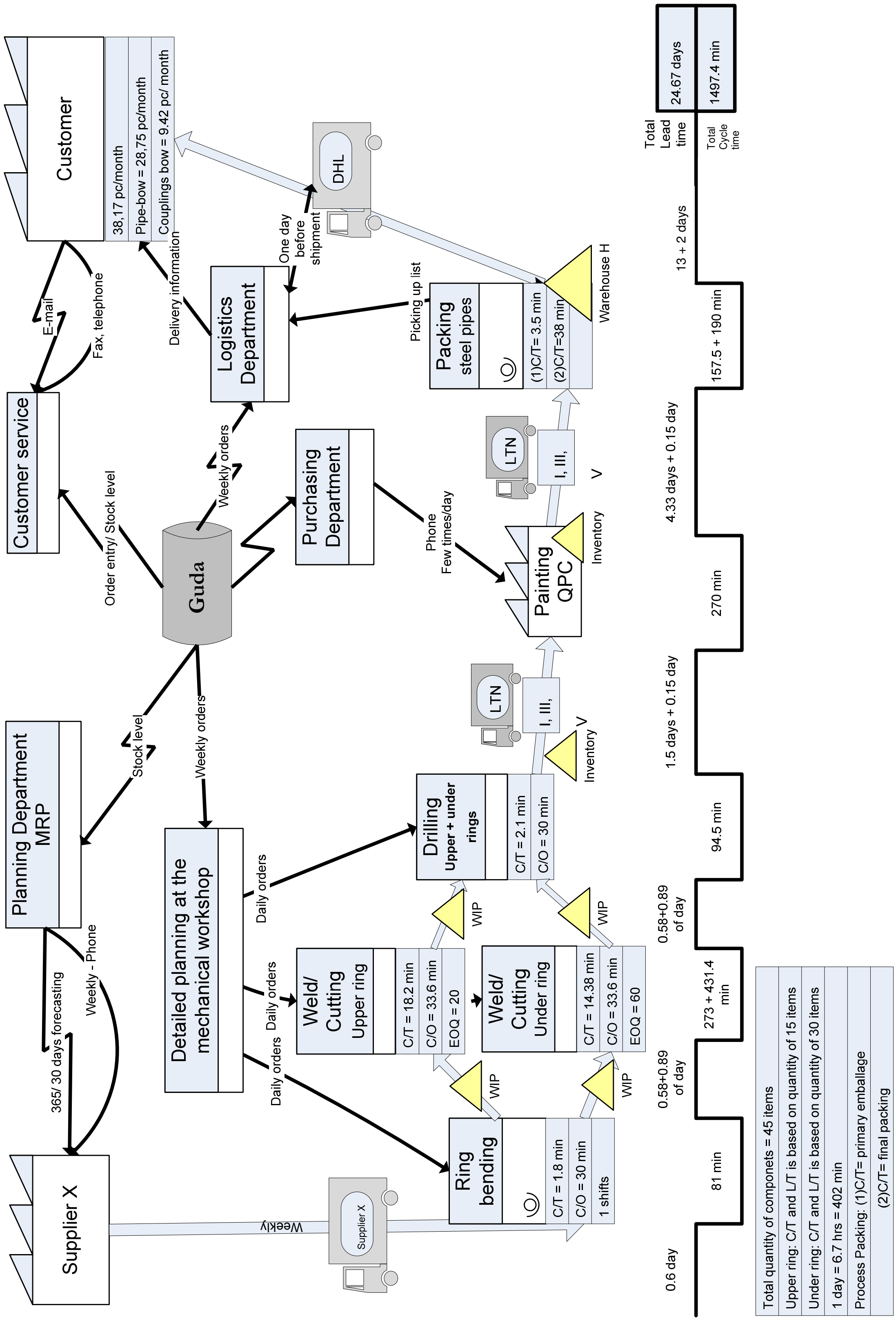

Physical pull


Pull arrow

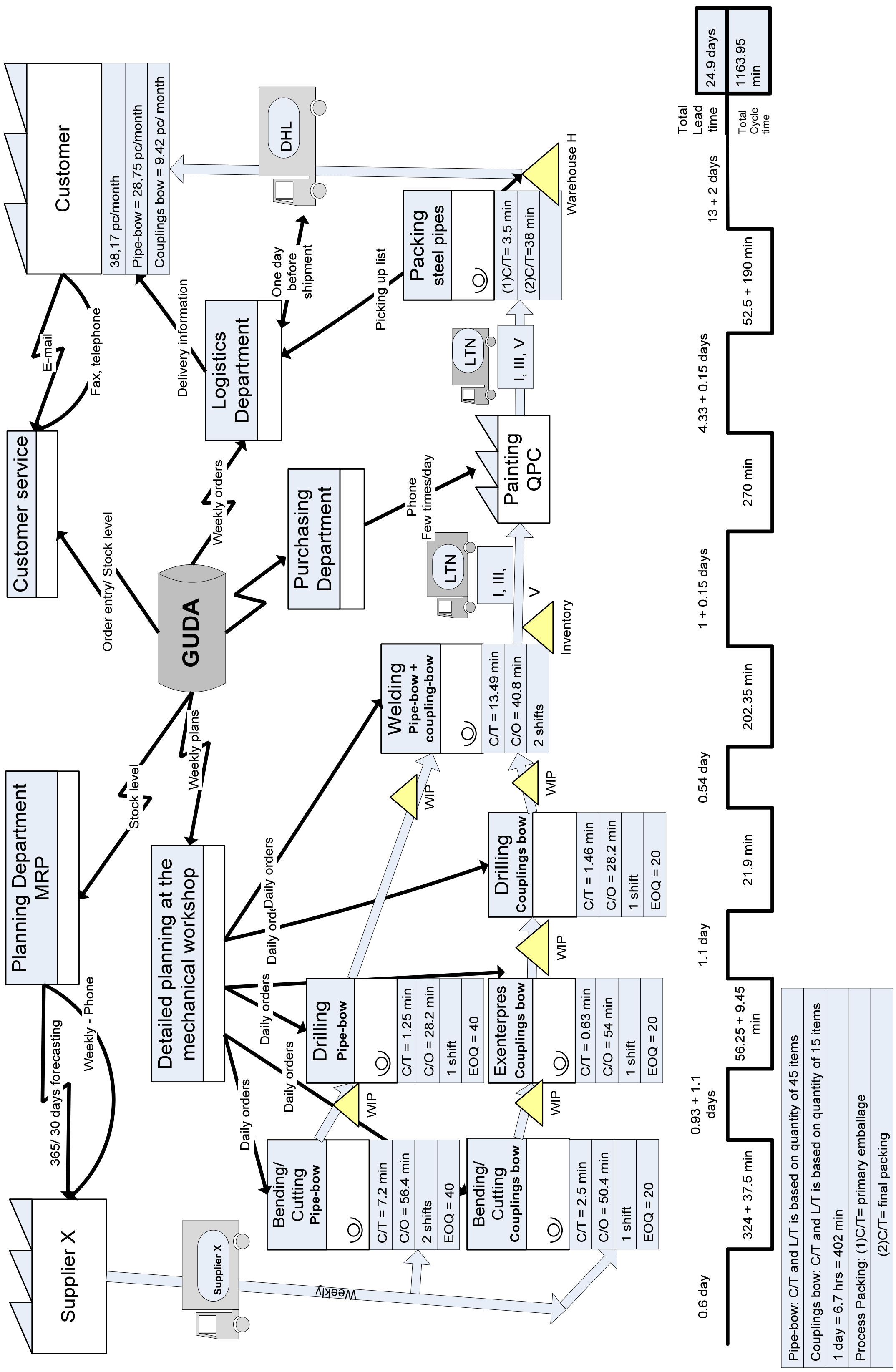
Appendix 5 – Current State Map
Process I - The flow of steel pipes of Origo components



Appendix 6 – Current State map
Process II - The flow of the rings of Origo components



Appendix 7 – Current State Map
Process III - The flow of Pipe-bows and Coupling-bow of Origo components



Appendix 8 – Table of Waste (ToW)

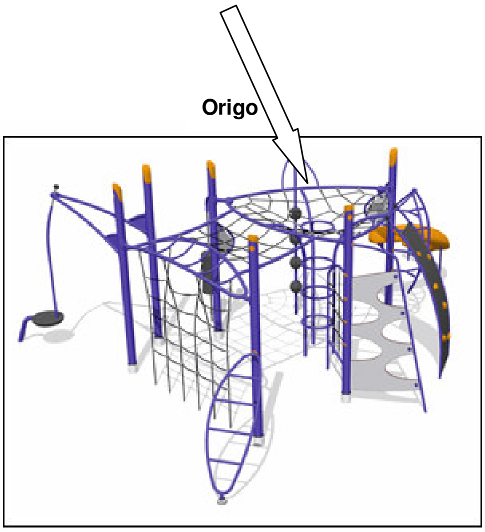
The 8 wastes were weighted on the basis of an average 5 point per waste with maximum of 10 and minimum of zero depending on the view of how important these different wastes are within the total process. Five managers at HAGS answered the ToW and the average of score was calculated with the total of 40 points.

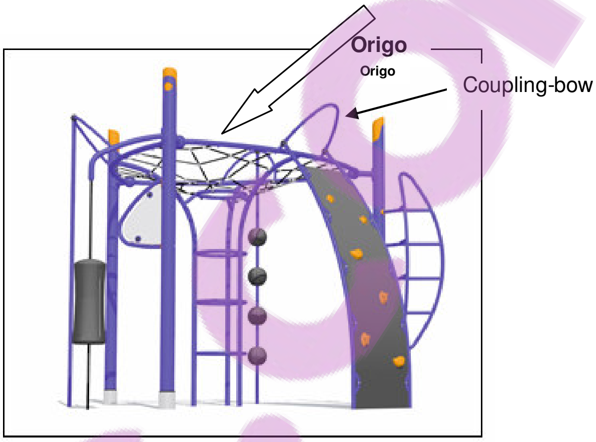
	Wastes	*Average weight of Hags*
1	Overproduction	4.8
2	Waiting	3.4
3	Transportation	5.4
4	Inappropriate Processing	4.8
5	Unnecessary Inventory	5.6
6	Unnecessary Movement	5.4
7	Deffects	6.4
8	Inappropriate Design	4.2
	Total	**40**

(Source: adapted from Hines & Rich, 1997)

Appendix 9 - HAGS Agito playing systems

“Origo is the heart of the entire Agito system” (HAGS homepage).





Appendix 10 – Draft of Future State Map