CHALMERS

# Applying Lean in Haulers' Operations

Master of Science Thesis

RIKARD LARSSON
EMMA WESTERBERG

Department of Industrial Management and Engineering
Division of Logistics and Transportation
CHALMERS UNIVERSITY OF TECHNOLOGY
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Division of Logistics and Transportation
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone + 46 (0)31-772 1000

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## Abstract

As a consequence of intense competition, rapid technology developments and changing markets haulers are facing increasing operational costs and low profit margins. To boost profitability and at the same time increase customer satisfaction this master's thesis shows that haulers could improve their competitive edge by taking a lean perspective on their operations. This could be achieved by defining what is value adding from the customer's perspective and eliminating or minimizing waste in their operations.

Many of the found issues in the haulers business have been studied in manufacturing environments when implementing lean production. Lean is both a philosophy and a set of methods that origins from Toyota. Today research is done on how lean can be applied in new settings such as health care, service industry et cetera. This master's thesis takes lean into a new field. Haulers' operations are studied in a detailed level, with the aim to minimize and eliminate waste.

By interviewing lean experts, hauler managers, business analysts and Volvo managers as well as conducting complementary observations of the haulers processes, a methodology to identify, visualize and measure waste in haulers' operations was designed. The methodology is tested and validated for the Swedish market. An important component in the methodology is an adaptation of Value Stream Mapping which supports the identification, visualization and measuring of waste in haulers' operations.

Application of the methodology revealed exempli gratia that 65 percent of the truck driver's working day was administrative work or handling of goods. With efficiency improvements this time can be assumed to decrease to 50 percent. The yearly cost for those 15 percentage points is illustrated in an example: assuming a work day of 8 hours, 220 work days per year, a cost of 220 SEK per hour for the driver and a cost of 70 SEK per hour for the truck; the cost will end up in 77 000 SEK per truck and year.

The purpose of the master's thesis was to develop a methodology to identify, visualize and measure waste in haulers' operations, using a lean perspective.



Keywords: *Transport, Lean, Lean production, Value Stream Mapping, Hauler, Waste*

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# Abbreviations

| Abbreviation | Explanation |
|---|---|
| CEO | Chief Executive Officer |
| ISO | International Organization for Standardization |
| IT | Information Technology |
| KPI | Key Performance Indicator |
| OD | Operational Development |
| OOA | Object Oriented Analysis |
| OOD | Object Oriented Design |
| PROPS | Project for Project Steering |
| RQ | Research Question |
| SC | Supply Chain |
| SCOR | Supply Chain Operations Reference |
| TPM | Total Productive Maintenance |
| TPS | Toyota Production System |
| TQM | Total Quality Management |
| VSM | Value Stream Mapping |
| WIP | Work In Process |

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# 1 Introduction

*The chapter introduces the master's thesis by providing a general background of the hauler's business. Further, the field of efficient transport is introduced. A problem area section will follow discussing theoretical and practical problems. This will be followed by the purpose, research questions of the master's thesis accompanied by the delimitations. The chapter is concluded with a section describing Volvo Technology, which is the initiator of the research project.*

## 1.1 Background

Today the road haulage business in Sweden faces a lot of challenges. The haulers are challenged by competition from other European countries and the haulers that do not follow the development in the market will have a rough time the next years. The trend during the last decade in the haulage business has been a consolidating market with a continuous decreasing number of companies and this is predicted to continue (Swedish Association of Road Haulage Companies, 2008). Results from a detailed inefficiency analysis on haulers, indicates huge financial losses due to inefficiencies. An example is the most frequently noted and costly inefficiency operation "time loading and unloading". This inefficiency is estimated to cost haulers over $3 billion annually (U.S. Department of Transportation, 2007).

For a future sustainable society it is a necessity to increase the resource utilization. The focus on efficient movement of goods has during the last years increased and all actors in the logistics chain know that it is necessary to have an efficient physical flow to optimize the resources available. A high degree of resource utilization when moving goods offers a possibility for higher profit margins, keeps the costs down and also has a positive impact on the capital tied up (Kanflo, 1999).

In a freight transport company, or hauler, the main task is to move goods from point A to point B, which is a part of a logistics chain (Brehmer, 1999). The demand for transports depends on several macro factors in the society such as economic cycles, location of manufacturing industries, demand for goods and services as well as geographical and infrastructural factors (Swedish Association of Road Haulage Companies, 2008). Factors that directly affect the business of a hauler are market conditions, taxes and laws, fuel prices, IT-development and the company's ability to develop its operations (Swedish Association of Road Haulage Companies, 2008). Several of these external factors cannot easily be influenced by the hauler. However, some internal factors are easier to influence, such as the company's ability to improve its own operations and optimize the resources available.

With globalization, outsourcing, technology and product life cycle changes; the complexity in the flow of goods has increased (Chrisopher & Lee, 2004). Increasingly complex transportation leads to unsynchronized transports that cause waiting times, slow reaction to upcoming events and lower filling rates. There can be a potential efficiency increase through actively managing and coordinating transportation operation between actors (Sternberg, 2008). The methods, services and technologies available influence the achieved efficient and cost effective transport. To match all this is hard in a dynamic environment (Brehmer, 1999). Today there are large volumes of goods in the supply chain and to move the goods in an efficient way is necessary. Because of the large amount of goods, a small change in the operational costs can lead to major differences in profit (Kärkkäinen, 2003).

Many of the above described issues have been studied in a manufacturing environment when implementing lean production (Brehmer, 1999). Lean originates from the success of Toyota. The way Toyota engineered and manufactured products, often phrased Toyota Production System, led to reliability in both the products and in the processes. Toyota manufactured cars both faster, with higher quality and to a more competitive price compared to other auto-makers (Liker, 2004). One of the main principles in lean is to find what is creating value for the customer. The aim is to reduce the non-value adding time, also called waste (Liker, 2004).

Today research is performed on how lean can be applied in new settings. This research will require a unique way for every industrial sector. Many sectors, for example low volume manufacturing and service environments, are still in the beginning of their lean evolution (Hines, et al., 2004). For a freight transport company, or hauler, the creation of value means that a specific service product meets the customer's needs at a specific place, price and time (Brehmer, 1999).

In this Master's Thesis value added activities are defined to when you move the goods closer to the receiver from the shipper. Delimitations in this thesis are to not look at fill-rate and route optimization. This leads to the assumption that the truck always drives the most optimize way and always is full loaded. A conclusion drawn from this is that all transport is value added time.

## 1.2 Problem Area

The trends towards smaller lot sizes and more frequent deliveries in the supply and distribution system require more resources in the system, although the actual volume of moved goods does not increase. This calls for more personnel and equipment for handling and moving goods, and the planning get more complex (Kanflo, 1999). If comparing passenger and freight transport, the people being transported generally return to their starting point. But when it comes to freight transports the goods generally only move in one direction. This creates a major logistical challenge to find backload for the returning vehicles. The utilization of the vehicle is very important for the efficiency of the transport operation. In the absence of returning goods the vehicle must return empty, often on the haulers expense (McKinnon & Ge, 2006). If a shipment is delayed to the terminal the shipment often has to wait 24-hours until next shipping cycle. Delays can be decreased by having better knowledge of transportation operations, access to up-to-date schedules, and being able to improve synchronization of transport operations and warehouse operations (Stefansson, 2004).

The Motor Carrier Efficiency Study (MCES) literature review revealed many types of inefficiencies in the haulers' operations (U.S. Department of Transportation, 2007). The study team identified 43 types of inefficiencies in the seven different categories; equipment / asset utilization, fuel economy and fuel waste, loss and theft, safety losses (i.e., crashes), maintenance inefficiencies, data and information processing, business and driver management. The study pointed towards that there are potential economics gains, both for the hauler and the society, in overcoming inefficiencies (U.S. Department of Transportation, 2007). In most haulers' operations fuel accounts stands for 30 percent of the operating costs and fuel management is preferable to achieve better operational efficiency. Another way to reach better operational efficiency is to specify the truck and make sure it really fits for the intended purpose. A question that is very important for the hauler is to measure. What do not get measured effectively cannot be managed effectively. In the hauler business there are many different aspects such as fuel consumption, accident reporting, tyre wear, and driver productivity et cetera.

To set targets to improve those will increase efficiency and help to monitor the internal performance and also to be able to benchmark (U.K. Department for Transport, 2009).

Various previous research studies have investigated supply chain uncertainties and developed models but have never considered transport as a strategic supply chain activity. Increasing operational costs and narrow profit margins makes the journey time reliability important and challenges the hauler to improve the efficiency of transport operation (Rodrigues, et al., 2008). The concept of identifying the value chain and the value adding time in the flow is seen as very important for a freight transportation company to achieve flexibility and to be able to give the customers a high level of service (Brehmer, 1999).

A study towards a model for lean operations in freight transport companies has been conducted by Brehmer (1999). One of the steps in the model is to make a process view from the customer's perspective and to move away from the functional viewpoint. This enables to set the right strategic goals and also to easier control that the acquired service level can be reached (Brehmer, 1999). Such a holistic approach is necessary to coordinate the activities and create effective transport operations. Studies have been made on how the information is used between the nodes and the links in the transportation operations and decision making. A mapping of the information flow between the participants and the activities has been executed to achieve a holistic approach (Sternberg, 2008). Sjöstedt (1994) has also studied the importance of the information flow. See Figure 1 for a description. He defines shipments as a part of a larger industrial production system. The system consists of flow of materials, components and products. These flows are pre planned and include many different producers. Co-operating producers and pre planning requires a well functioning information system (Sjöstedt, 1994).

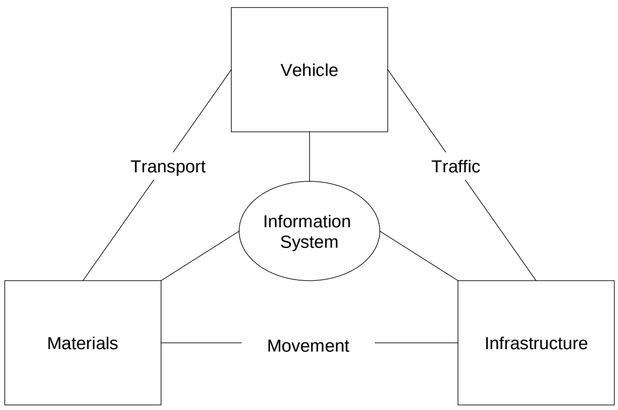


**Figure 1: Simple Logistic System, adapted from Sjöstedt (1994).**

Research has been done on the process flow with focus on the supply chain operations and the information flow but research of the haulers' operations is still inadequate. This calls for a closer look into the operations of the hauler. A possible research approach to this incomplete field is to take a bottom-up perspective; starting from a value adding flow of goods. Inspired by both the success of lean in many applications and the focus on the value flow optimization this master's thesis will take a new perspective on research of efficiency in haulers' operations.

## 1.3 Purpose

The purpose of the master's thesis is to develop a methodology to identify, visualize and measure waste in haulers' operations, using a lean perspective.

## 1.4 Research Questions

From the described background and the theoretical and practical problems highlighted in the problem area section the following research questions (RQs) are derived.

> *RQ 1: What type of waste can be identified in a hauler's operations?*
> The question aims to reveal what different types of waste that could exist in haulers' operations. The different types of waste will be the fundament for future improvements.
>
> *RQ 2: How can the waste be identified?*
> Assuming waste exists in haulers' operations, the question aims to examine how waste can be identified by a systematic methodology.
>
> *RQ 3: How can the identified waste be visualized?*
> To facilitate the understanding and communication of the identified waste, a way to visualize waste is desirable.
>
> *RQ 4: How can the identified waste be measured?*
> By measuring the identified waste the impact can be understood and actions that will be taken can be properly prioritized.

## 1.5 Delimitations

The scope of the master's thesis is the transport of goods and operations that are directly linked with, and affects, the transportation of goods. Such a direct linked process is the order-to-cash process. Other indirectly related processes, such as purchasing, are not included in the master's thesis.

The purpose of the master's thesis is not to design a framework for a complete lean transformation. The developed methodology will focus on the identification, visualization and measuring of waste in haulers' operations.

Through this thesis, the methodology is validated in the Swedish market. The intention is that the methodology could be used in other areas but this is not validated through this thesis.

The methodology is tested and validated for distribution and short-haul. The methodology has not been tested for long-haul but the intention is that the methodology could be applied in this field as well.

Two aspects that are considered important for the haulers, fill-rate and route optimization are not covered in this master's thesis. During the initial phase of the master's thesis it was found that these aspects affect haulers business, but it would be to complex and time consuming to take both in consideration during the development of the methodology.

## 1.6 Volvo Technology

Volvo Technology is the centre of innovation, research and development within the Volvo Group. The mission is to develop existing and future technology areas of high importance to Volvo. The customers include all Volvo Group companies, Volvo Cars and some selected suppliers. Volvo Technology participates in national and international research programmes, involving universities, research institutes and other companies. The competencies are many and include e.g. telematics, ergonomics, logistics, combustion, electronics and mechanics.

One of Volvo Technology's missions is to secure the strategic concepts for the Volvo Group. Volvo Group is facing challenges and must like many other companies improve performance and continuous search for new markets and opportunities to gain higher profits from their business (Volvo Group, 2007).

As a leading manufacturing company, Volvo Group has begun the journey from delivering stand-alone products to complete solutions. The intention by Volvo Group is to position itself in relation to its competitors and develop a closer relation to its customers. The master's thesis is a part of Volvo Groups intention to strengthen the understanding of the customer needs.

# 2 Frame of Reference

*The chapter introduces the frame of reference used in the master's thesis. The chapter covers key concepts such as haulers business, lean and related concepts, process mapping, Key Performance Indicators and other relevant theories for the master's thesis.*

## *2.1 Haulers*

Our community is depending on freight transports. The major part of goods moving today is transported by a haulage company (Swedish Association of Road Haulage Companies, 2008). The following sections introduce the haulers role in the network and the market situation of the hauler business.

### 2.1.1 The Haulers Role in the Network

The logistic system involves many actors. Figure 2 shows the key actors in the logistic system. There are external actors such as the customers and the society, who sets the rules for the system. There are also supplier and goods mover which have the responsibility for, and carry out, the processes of the logistic system. The goods mover is the one responsible for moving the goods between two businesses (Jonsson & Mattsson, 2004).

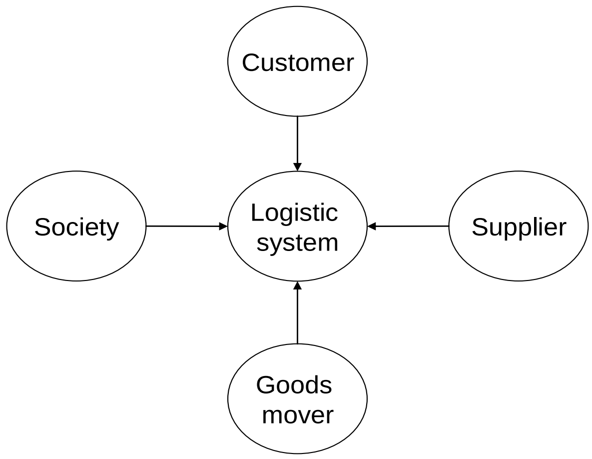


**Figure 2: Actors in the logistic system, adapted from Jonsson and Mattsson (2004).**

The goods mover can be road, rail, boat or flight transportation. Swedish Association of Road Haulage Companies (2008) points out that road and rail transports complement each other rather than competes. They further say that some transports compete, but the overlapping area for road and rail is limited. There are around 420,000 km of road where the road transports can operate, while rail is limited to around 11,000 km of railway.

### 2.1.2 Market Situation of the Hauler Business

The haulers are depending on the market situation in society and they have to follow ongoing trends in the business. The demand on transportation is linked directly to how big the market for goods and services is. Economical growth, industry development and industry location affect the demand for transports. Today the market is moving towards a more international arena and EU-regulations affects the haulers. Factors such as Information Technology (IT) and security aspects become more and more important. A well functioning IT-system can for example help a hauler to link the traffic control and planning, order handling and economic system together. The freight transport impact on the environment is also very essential.

Efficient logistic planning and eco-driving are two central points in the effort to lower the carbon dioxide ($CO_2$) emissions (Swedish Association of Road Haulage Companies, 2008). Professional road transport is driving economic, social and environmental progress all over the world. Road transport has become a production, distribution and mobility tool. Due to its unique door to door service, road transport is linking business to all world markets and one can say road transport is central for economic growth and competitiveness (International Road Transport Union, 2009).

## 2.2 Lean

Womack et al. (1990) describes lean production as following:

> *'Lean production uses less of everything compared to mass-production. Half the human effort in the factory, half the manufacturing space, half the investment of tools, half the engineering hours to develop a new product in half time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products.'*

Lean is often misunderstood as only a set of methods and techniques to improve the production of a company. Hines, et al., (2004) addresses this issue and suggest that a distinction between the strategic level and the operational level should be done to fully understand lean as a whole. Figure 3 illustrates this distinction between the strategic level, "lean thinking", and the operational level, "lean production", and how other methods such as Total Quality Management (TQM) and Total Productive Maintenance (TPM) can be incorporated.

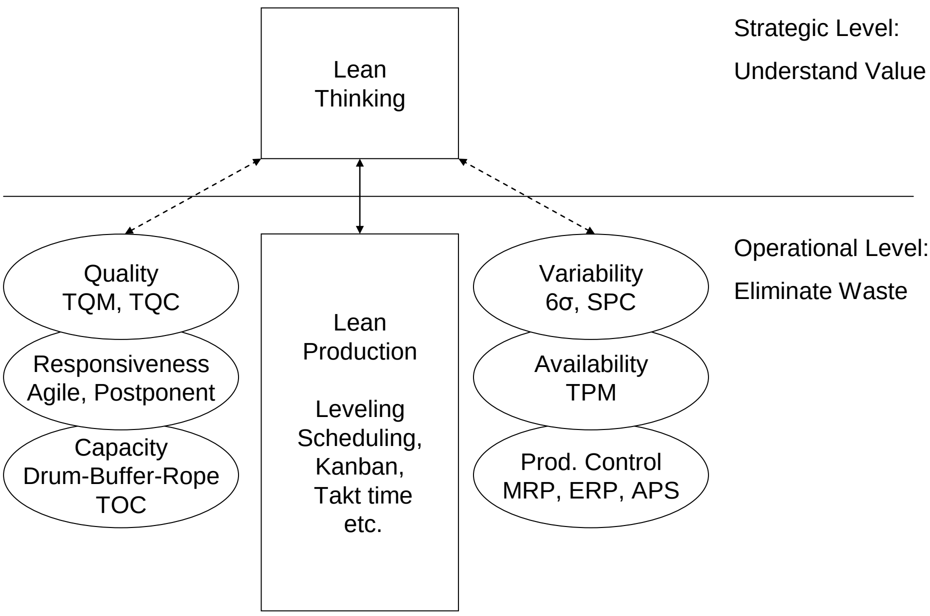


**Figure 3: Lean framework, adapted from Hines, et al., (2004).**

One of the Toyota Production System (TPS) principles is to create a continuous flow to bring the problems to the surface. This is a good place for any company to begin the journey towards becoming lean. In business processes there are often a lot of waste and the time from raw material to finished goods is longer than necessary. To achieve the best quality, lower cost and shortest delivery time the waste have to be distinguished from the value-adding time (Liker, 2004).

### 2.2.1 Waste

Liker (2004) describes the application of TPS in a manufacturing setting. The first question asked should be: "What does the customer want from this process?". This defines value according to Liker (2004). Through the customer's eyes a process can be separated into value-adding steps and non-value-adding steps, also called waste. Liker (2004) points out that the application is also valid for other processes other than manufacturing processes, such as information or service processes.

Toyota has identified seven major types of waste in manufacturing and business processes (Liker, 2004). In addition to these seven forms of waste Liker (2004) has included an additional form of waste, unused employee creativity. Table 1 lists the eight forms of waste.

**Table 1: Eight forms of waste, adapted from Liker (2004).**

| Waste | Description |
|---|---|
| Overproduction | Producing items for which there are no orders, which generates such waste as overstaffing and storage and transportation costs because of excess inventory. |
| Waiting (time on hand) | Workers merely serving to watch an automated machine or having to stand around waiting for the next process step, tool, supply, part, etc. or just having no work because of stock outs, lot processing delays, equipment downtime, and capacity bottlenecks. |
| Unnecessary transport or conveyance | Carrying Work In Process (WIP) long distances, creating inefficient transport, or moving materials, parts or finished goods into or out of storage or between processes. |
| Overprocessing or incorrect processing | Taking unneeded steps to process the parts. Inefficient processing due to poor tool and product design, causing unnecessary motion and producing defects. Waste is generated when providing higher-quality products than is necessary. |
| Excess inventory | Excess raw material, WIP, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay. Also, extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times. |
| Unnecessary movement | Any wasted motion employees have to perform during the course of their work, such as looking for, reaching for, or stacking parts, tools, etc. Also walking is waste. |
| Defects | Production of defective parts or correction. Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort. |
| Unused employee creativity | Losing time, ideas, skills, improvements, and learning opportunity by not engaging or listening to your employees. |

Overproduction is often seen as the worst form of waste since it creates other forms of waste in the company (Hines & Rich, 1997).

In traditional improvement work, the focus is often to optimize the value adding processes and this gives limited improvements. There are more potential if one attacks the necessary waste and the pure waste (Blücher & Öjmertz, 2006). This is illustrated in Figure 4.

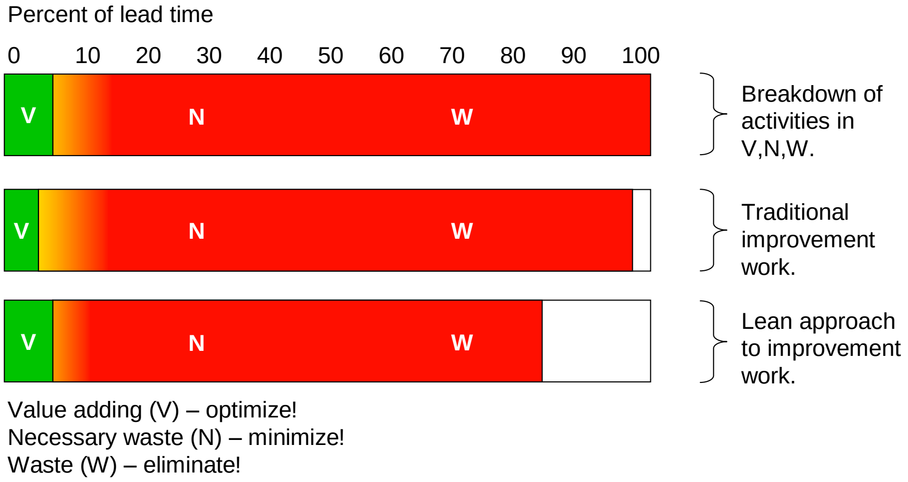


**Figure 4: Value adding processes, necessary waste and pure waste, adapted from Blücher and Öjmertz (2006).**

### 2.2.2 Lean beyond Production Environment

Womack, et al., (1990) argues that lean production is a universal set of management principles that could be applied equally in every industry across the globe. This statement can be questioned, but numbers of successful applications of lean production in other industries exist in the literature (Hines, et al., 2004). Piercy and Rich (2009) find that lean shows much validity in the service context, specifically the value identification, mapping of value, work place redesign and work task changes. Souza (2009) says that lean still is in the early stages of development in the health care industry if you compare it to the automotive industry. He further means that lean has big potential in the health care industry but academics and practitioners have a big challenge to evaluate this. Other examples besides the manufacturing industry is the application of lean in the fields of energy and environment (Environmental Protection Agency, 2003), administrative and office processes (Keyte & Locher, 2004) and food industry (Simons & Zokaei, 2006) just to mention a few.

## *2.3 Key Performance Indicator*

To be able to make well-informed, tactical and strategic decisions it is important to accurately measure the resources used to deliver good service for the customers. The starting point for any performance improvement programme should be to understand the current performance of the operations. By collecting data on key aspects of the operations and turning this information into specific measures areas for improvement can be identified. These measures are often known as Key Performance Indicators (U.K. Department for Transport, 2008).

An individual Key Performance Indicator (KPI) can be useful to assess performance in a single operational area such as fuel consumption. By combining several KPIs it is possible to get an overview of the company’s performance in more general terms, such as revenue, profitability, overall fleet efficiency et cetera.

The Performance Management for Efficient Road Freight Operations Guide (U.K. Department for Transport, 2008) discusses the use of 24 different KPIs categorized in six groups; cost, operational, service, compliance, maintenance and environmental. Table 2 shows the categories, the associated KPIs and a brief description.

**Table 2: Key Performance Indicators, adapted from U. K. Department of Transport (2008).**

| Area | KPI | Description |
|---|---|---|
| Cost | Average cost per unit delivered (SEK) | Average cost of delivering a specified unit (e.g. a pallet or tonne of goods) |
| | Total whole vehicle cost (SEK per km) | Total cost of your fleet per mile. Made up of running, standing and driver costs |
| | Average running cost (SEK per km) | Average cost of running your fleet per mile. These are the costs incurred for running the vehicles (fuel, tyres and maintenance) |
| | Average standing cost (SEK per km) | Average standing cost for your fleet. Standing costs are those incurred whether or not the vehicle is running - depreciation of the vehicle, road fund licence (vehicle excise duty), operator licence fees and insurance |
| | Average driver cost (SEK per km) | Average cost of drivers’ wages per mile |
| | Total maintenance cost (SEK per km) | Total cost of maintaining the fleet per mile |
| | Total maintenance cost (SEK) | Total cost of maintaining the fleet |
| Operational | Average km per litre | Average fuel consumption rate for your fleet |
| | Total km run | Total number of miles run by your fleet |
| | Total empty km run | Total number of miles run by your fleet without a payload |
| | Percentage empty running total | Percentage of distance run by your fleet without a payload |
| | Percentage Average vehicle fill | This calculates the percentage of actual load carried against the potential capacity of the vehicle fleet |
| | Percentage Average time utilisation | This calculates the percentage of time that the vehicle fleet was actually in use against the potential time available |
| Service | Percentage of late deliveries total | Percentage of late deliveries made by your fleet |
| | Percentage of damages total | Percentage of deliveries made by your fleet where the goods were either missing or damaged |
| | Percentage of complaints total | Percentage of deliveries made by your fleet that resulted in a complaint of any nature |

| Area | KPI | Description |
|---|---|---|
| Compliance | Total number of overloads | Total number of overloads in the fleet |
| | Total number of vehicle traffic infringements | Total number of traffic infringements in the fleet |
| | Total number of drivers' hours infringement | Total number of drivers' hours infringements in the fleet |
| | Total number of traffic accidents | Total number of traffic accidents in the fleet |
| Maintenance | Percentage of failed inspections total | Percentage of failed or overdue safety inspections for your fleet |
| | Percentage of defects rectified in 24 hours total | Percentage of vehicle defects reported by drivers that are rectified within 24 hours |
| Environmental | Total fleet CO2 | Total CO2 produced by fleet (tonnes) |
| | Average fleet CO2 | Average CO2 produced by fleet (kg/km) |

## *2.4 Process Mapping*

Process mapping enables visualization and analysis of business processes. A process map can control the activities of an organization and increase process visibility. In many companies the development of process maps is a way to find process improvements (Klotz, et al., 2008). At Toyota people are educated on three flows in the manufacturing setting: the flow of material, the flow of information and the flow of processes (Rother & Shook, 1998). Hibberd and Evatt (2004) points out three factors why it is important to map information flow:

- It enables the understanding of how information is used and by whom.
- It pinpoints the ultimate client or key stakeholder for various types of information services, as well as where information touches as it passes through the organization.
- It helps to focus information services in the highest potential opportunities.
- The following sections will describe three types of process mapping; Value Stream Mapping (VSM), Supply Chain Operations Reference Model (SCOR) and Object Oriented Design (OOD).

### 2.4.1 Value Stream Mapping

To help manufacturers learn about the Toyota Way the VSM tool was developed with the intention to give manufacturing companies lasting improvements and find the roots of waste. The VSM tool is seldom used at Toyota plants where the method is called "Material and Information Flow Mapping" (Rother & Shook, 2003). When discussing VSM focus should be on the big picture and not to optimize parts or individual processes; maybe one has to follow the value stream through many companies and facilities. This is often too much to start with when beginning the lean implementation and the mapping, but this is the aim to strive for in the long-term perspective (Rother & Shook, 2003).

There are other methods that are similar to the VSM method but literature review shows that those existing tools neither cover the same framework as VSM, nor the same degree of completion of the manufacturing system (Lasa, et al., 2008).

The VSM tool is simple a pencil and paper tool that helps to understand the material and information flow. One product family are followed through the plant by walking the flow and observing the processes. It is suggested to ask key questions to find the waste points. The Value Stream will be drawn up carefully and every process in the current state is measured. After drawing the current state an improved future state is drawn. As organizational boundaries are crossed it is recommended to have someone responsible for the Value Stream. This person is often called Value Stream Manager (Rother & Shook, 2003). Figure 5 illustrates the perspective of a Value Stream Manager.

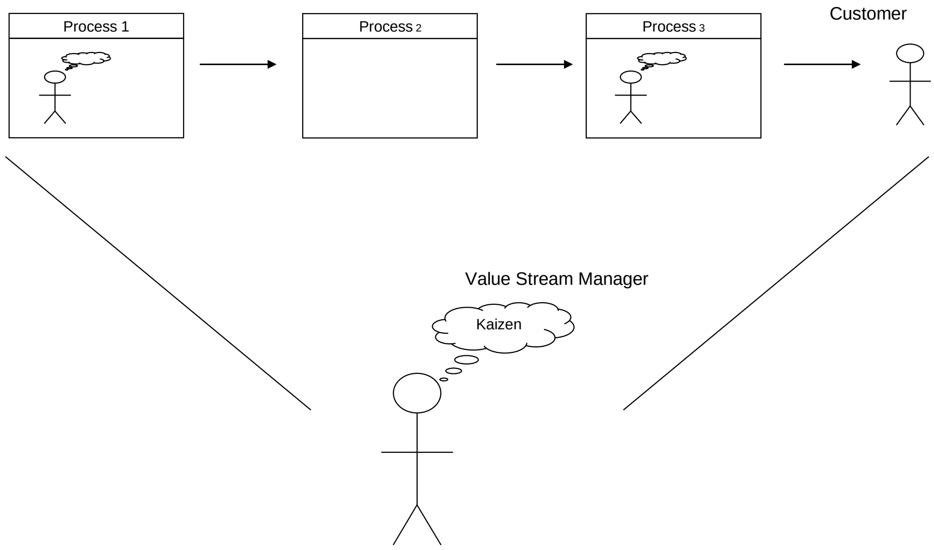


**Figure 5: Value Stream Manager, adapted from Rother and Shook (2003).**

## 2.4.2 Supply Chain Operations Reference Model

Supply Chain Operations Reference (SCOR) model is the most promising model for supply chain strategic decision making (Huan, et al., 2004). SCOR is a process mapping tool with four distinct processes; source, make, deliver and plan. Every source, make and deliver "chain" is a basic supply chain and every interaction of two "chains" is a link. The planning process has an overview of these links with the purpose to manage them. This is illustrated in Figure 6. The processes are divided into process elements, tasks, and activities. While the SCOR model provides a full set of supply chain performance metrics and business best practice, the model allows firms to do an analysis based on facts, including all aspects of the supply chain (Huan, et al., 2004).

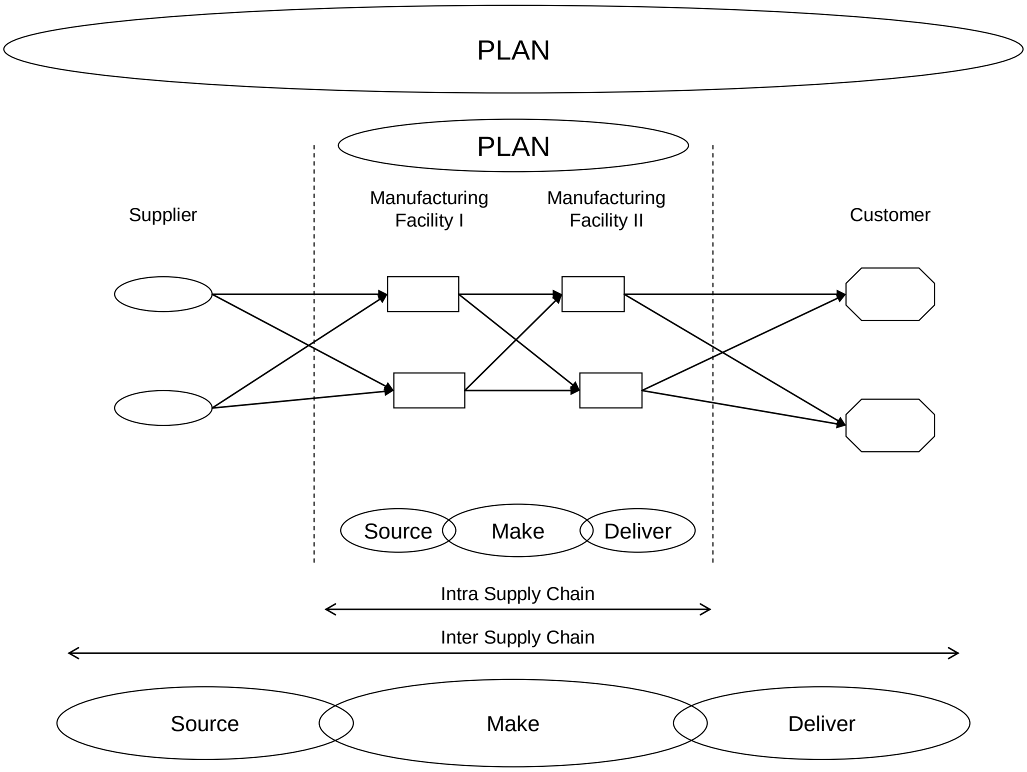


**Figure 6: The SCOR model based, supply chain infrastructure, adapted from Huan, et al., (2004).**

### 2.4.3 Object Oriented Design

With various motives and results, object oriented modelling and analysis is used in the field of transportation and logistics. The object oriented framework provides several possibilities for powerful visualization tools. Object oriented analysis (OOA) is a well-functioning way to analyse a system which consist of an object model. Object oriented design (OOD) is used to construct models of future systems based on the OOA. The diagrams used in object orientation have one advantage compared to other visualization models. They are a part of a large framework which includes several aspects such as, states, transitions, sequencing, relationships, message passing et cetera (Arnäs, 2007).

# 3 Research Method

*The chapter introduces the research method used in the master's thesis. The first section describes the research strategy followed by a section on how data collection is executed. The chapter is concluded by a discussion regarding the master's thesis reliability, validity and objectivity.*

## 3.1 Research Strategy

To fulfil the purpose of the master's thesis the research strategy illustrated in Figure 7 has been used. The first phase is defining the aim of the master's thesis. The resulting purpose and research questions are presented in section 1.3 and 1.4. The next phase is a literature study covering key concepts within the fields of lean, hauler, process mapping, Key Performance Indicators and other relevant topics. The following phase is a set of interviews which were conducted with different stakeholders related to the haulers business. The interviews are accompanied by observations to complement the collected data in the interviews. The next phase is the design of a methodology focusing on identifying, visualizing and measuring waste in haulers' operations. The following phase is a test phase of the methodology. After testing the methodology the methodology is validated in a case study. The final phase is delivery of the results of the master's thesis.

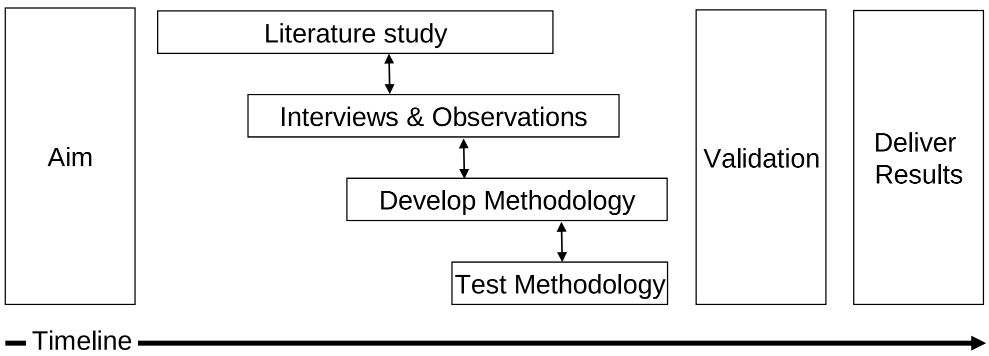


**Figure 7: Research strategy used in the master's thesis.**

## 3.2 Data Collection

The collected data consist of both primary and secondary data. The main sources of primary data are interviews, observations and the test case and the validation case of the methodology. The primary source of secondary data is various type of literature from the literature study. The reader is referred to the reference chapter for a complete list of literature used in this master's thesis.

### 3.2.1 Literature Study

The initial phase in the data collection phase is a literature study covering a number of different types of sources and different types of literature. The outcome of the literature study is presented in chapter 2. The literature study is also used to design the framework for primary data collection and to support the analysis and methodology design. The intention is to choose scientific and unbiased literature and journal articles as the first choice and only use newspaper articles, company internal information, consultancy reports et cetera when academic literature is not available.

Table 3 shows the search terms used in the literature search. Combinations of the listed search terms have been used with Boolean logic such as “OR” and “AND” function.

**Table 3: List of search terms used in the litterateur study.**

| Search term | Database |
|---|---|
| Hauler | Emerald, Science Direct |
| Haulier | Emerald, Science Direct |
| Carrier | Emerald, Science Direct |
| Haulage business | Emerald, Science Direct |
| Lean | Emerald, Science Direct |
| Lean production | Emerald, Science Direct |
| Lean thinking | Emerald, Science Direct |
| Lean transportation | Emerald, Science Direct |
| Service provider | Emerald, Science Direct |
| Waste | Emerald, Science Direct |
| Process Mapping | Emerald, Science Direct |
| Supply Chain Operations Reference Model | Emerald, Science Direct |
| Value Stream Mapping | Emerald, Science Direct |
| Performance management | Emerald, Science Direct |
| Key Performance Indicator | Emerald, Science Direct |

### 3.2.2 Interviews

Interviews are conducted with four different categories of actors related to the haulers’ operations. By interviewing different persons in different positions it is the authors’ intention to create a holistic understanding of the haulers business and to facilitate the design of the methodology to identify, visualize and measure waste in haulers’ operations.

Table 4 shows a list of the interviews conducted in this master’s thesis. An overview of the interviews can be found in Appendix C.

By interviewing hauler operational managers it is possible to get the CEO’s perspective of waste in haulers’ operations and a perspective on their own business and its operations. Another aim by interviewing hauler CEOs is to get an insight in the top management’s daily work and their role in the organization.

The lean perspective of the study is strengthened by interviewing several lean experts. This will complement the study with the lean experts’ view of haulers’ business. Another aim is to acquire knowledge of the lean experts’ previous work experience with identifying, visualizing and measuring waste. In addition it is possible to get an understanding of the lean experts’ point of view of applying lean in haulers’ operations.

In addition both business analysts and Volvo managers are interviewed. The objective is to both acquire knowledge of the business analysts’ experience from measuring performance and a truck manufactures perspective of waste in haulers’ operations. An objective is also to complement the study with their experience from the road transport business.

**Table 4: Interviews conducted in the master's thesis.**

| Name | Company |
|---|---|
| Hauler Operational Manager 1 | Mid size hauler located in Sweden |
| Hauler Operational Manager 2 | Mid size hauler located in Sweden |
| Hauler Operational Manager 3 | Mid size hauler located in Sweden |
| Lean Expert 1 | Lean Consultant |
| Lean Expert 2 | Lean Consultant |
| Lean Expert 3 | Lean Researcher |
| Lean Expert 4 | Lean Researcher |
| Lean Expert 5 | Lean Researcher |
| Business Analyst 1 | Volvo Retailer |
| Business Analyst 2 | Volvo Group |
| Business Analyst 3 | Volvo Group |
| Volvo Manager 1 | Volvo Group |
| Volvo Manager 2 | Volvo Group |
| Volvo Manager 3 | Volvo Group |

In the phase of developing the methodology to identify, visualize and measure waste semi-structured interviews are conducted. The intention is to give a sufficient structure to cover different topics and still give the respondent enough freedom to elaborate on interesting topics not chosen by the interviewer. In a later phase, when testing and validating the methodology a combination of structured and semi-structured interviews are used.

Bryman and Bell (2007) discusses several important aspects of the interviewing process. They suggest that when preparing the interview guide the questions should be formulated in a way that that will help to answer the research questions. The interview guide in this master's thesis is structured in four sections, each one corresponding to one of the research questions. The intention is that this facilitates the linkage between the interview questions and the research questions. The Case Study Protocol used in the interviews can be found in Appendix A.

Another aspect of the interview process discussed by Bryman and Bell (2007) is the different criteria of a successful interviewer. The authors means that structuring the interview, giving clear questions, being sensitive an listening attentively and being ethically sensitive is some important factors. It is the authors intention to follow this advice when conduction the interviews.

### 3.2.3 Observation

To complement the interviews conducted with the different actors as described in the section 3.2.2 observations both on site at the haulers and by following the truck driver in the daily work is conducted. Yin (2006) argues that participant observation is a specific form of observation. The observer acts more than just a passive observer and one advantage is the possibility to get an insider view of the studied object and not only an external objective view. Yin (2006) also discuss the risks with participating interviews and argues that there is a risk with skewness of the collected data. Bryman and Bell (2007) suggest that participant observation is a well known method of data collection and by using the method the observer can interact with the observed.

By using the participant observation method observing both employees at the office and drivers performing their daily work the intention is to understand the operations and be able to distinguish what kind of activities performed that could be classified as value adding, necessary waste and pure waste.

## *3.3 Reliability, Validity and Objectivity*

Patel and Davidson (2003) argues that high reliability does not guarantee high validity but high reliability is a prerequisite for high validity. The following sections will discuss the master's thesis reliability, validity and objectivity.

### 3.3.1 Reliability

The goal of reliability is to minimize the errors and biases in the study (Yin, 2006). Ryen (2004) suggest that reliability in qualitative research can be increased by recording interviews, documenting the research process and presenting more than just summaries of the collected data. Ryen (2004) also argues that reliability could be increased by letting other researchers categorize collected data and then comparing the results of the categorizing.

High reliability in this master's thesis is ensured by a standardized interview process using the Case Study Protocol in Appendix A. The interview is well prepared and the purpose of the interview and time frame is explained for the interviewee. The interviews are transcripted by both authors and compared afterwards to see if both authors interpret the data in the same way. This ensures a high quality level of the collected data. When questions arise regarding how the collected data should be interpreted, other researchers can be consulted since the interviews are transcripted. Documenting the research method itself is another way to increase quality of the collected data.

An additional approach to increase reliability in the study is to use triangulation (Bryman & Bell, 2007; Björklund & Paulsson, 2003). Björklund and Paulsson (2003) suggest that the use of different methods and different sources of data is one way to triangulate. In this master's thesis different persons will be interviewed who are assumed to have different point of views and experience from the transport business. The interviews are complemented by observations in the haulers daily work. This could be argued to be another way to triangulate.

### 3.3.2 Internal and External Validity

Yin (2006) discusses validity in the terms internal validity and external validity related to case study research. Yin (2006) argues that the problem with internal validity relates to that the researcher wants to draw sustainable conclusions. Yin (2006) further describes the research process and argues that the researcher will draw conclusions based on collected data at a moment that can not be exactly defined.

This process is handled in this master's thesis by using an analytic work process model to describe how the theory and collected data is linked to the analysis and the defined research question.

External validity relates to the possibility to generalize the findings outside the current case study (Yin, 2006). Case studies have been criticised to be too vulnerable to be generalized. The case study research method is often compared to survey research and the critics mean that survey research easily can be generalized from a sample to a whole population. Yin (2006) argues that this is wrong and means that the comparison is wrong; survey research is based on statistics and case study research is based on analytic generalizations.

The approach to ensure external validity in this master's thesis is the test pilot case study of the developed methodology and the replication of the case study with the validation case study to be able to generalize the findings. By doing such a replication the theory can be regarding as having strong support according to Yin (2006).

The triangulation approach discussed in section 3.3.1 can also increase validity according to Björkman and Paulsson (2003).

### 3.3.3 Objectivity

Björkman and Paulsson (2003) argue that clarifying and motivating the choices made in the master's thesis will increase the objectivity.

Paulson (1999) discusses the influence of an originator as the initiator of a research project and how that can influence the objectivity. Paulsson (1999) argues that it is important to listen to advice and suggestions from the originator but stresses the importance that all the decision should be taken by the researcher. In this master's thesis the authors will be open for suggestion and advice from the originator but we will not forget the importance of taking all decisions by ourselves. Paulsson (1999) also stresses the importance of having insight in this challenge.

# 4 Empirical Study

*This chapter presents the conducted empirical study described in the research method chapter. The empirical data is presented in four sections corresponding to each of the four research questions presented in the introduction chapter. The interviewees are divided into four different groups; Hauler Operational Manager, Lean Expert, Business Analyst and Volvo Manager to give a better overview of the results. The main findings from these four groups are summarized in a table in each section. The case study protocol for respective interview is presented in Appendix C.*

## 4.1 *Waste in Haulers' Operations*

The following section presents the part of the empirical study that concerns waste in haulers' operations. Throughout the empirical study different types of waste were found. In the following sections information flow and planning, fuel consumption, utilization of resources, loading and unloading process, administrative processes and pricing model, and vehicles and drivers will be presented.

### 4.1.1 Information Flow and Planning

**Table 5: Waste related to information flow and planning.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Lack of route optimization. | Information flow between traffic control and driver. | Information flow between traffic control and driver. | Lack of route optimization. |
| | Short term planning horizon. | Lack of IT-support. | Lack of communication. |
| | Dependent upon ferry schedules and driving hours. | Lack of route optimization. | |
| | Choice of route and road fees. | | |

Several of the interviewees mention information flow within the organization and planning of the transportation as wasteful operations. Hauler Operational Manager 1 describes their ongoing work to optimize their distribution routes to free up resources which can be used in other areas. Involvement of the drivers is a key success factor for these route optimizations.

Lean Expert 2 experienced problems with communication and planning when he travelled together with a driver through Europe. The planning horizon from the traffic control was very narrow. They picked up goods in Sweden and delivered it to a factory in central Europe. It was a question of chance if and when someone called from the traffic control and gave instructions what they should pick up on their way back to Sweden. Lean Expert 2 also explains how important the ferry schedules and laws regulating driving hours et cetera are. Another aspect is the choice of route and the cost of road fees according to Lean Expert 2.

Business Analyst 3 mentions a hauler he worked with and explains the faulty information flow between traffic control and the driver. There is no supporting IT system to facilitate the exchange of information between the traffic control and the drivers. Instead of using an IT system the driver has to visit the office several times a day to collect and report transport assignments. The traffic control can best be described as chaotic with the traffic controller speaking in two phones simultaneously while printing orders and trying to keep control of everything. Another aspect mentioned by Business Analyst 3 is the potential of route optimization. Business Analyst 3 argues that the potential for improvements depends on the type of transport. For example distribution has a higher potential for improvements with route optimization while it is more difficult to improve routing for long hauls.

Volvo Manager 3 also discusses the importance of route optimization and the waste associated when a chosen differs from the optimal route. Volvo Manager 3 concludes that it is important to deliver the right things at the right time and choosing the right way.

### 4.1.2 Fuel Consumption

**Table 6: Waste related to fuel consumption.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Unnecessary high fuel consumption. | [Not discussed] | Large difference in drivers' behaviour. | Unnecessary high fuel consumption. |
| Driver behaviour such as idle driving. | | Education in eco driving. | Large portion of the total cost. |
| Difficult to measure and follow up fuel consumption. | | System to follow up fuel consumption necessary. | |

Unnecessary high fuel consumption due to various reasons is discussed by many of the interviewees. Hauler Operational Manager 1 refers to idle driving as a driver behaviour that causes unnecessary waste. Hauler Operational Manager 3 means that high fuel consumption causes high costs for their company. Unfortunately it is difficult to follow up the fuel consumption for the company. This result in difficulties with applying counter measures to lower the fuel consumption.

According to Business Analyst 1 the difference between the best and the worst driver can be up to 20 to 30 percent difference in fuel consumption for the same transport assignment. The difference is related to the driver's behaviour. A lot of unnecessary waste can be saved with eco driving education and a system to follow up the fuel consumption.

Both Volvo Manager 2 and Volvo Manager 3 mention the fuel consumption and say that it is an important source of waste. Volvo Manager 2 exemplifies that approximately 30 percent of the costs in haulers' operations are related to the fuel consumption.

### 4.1.3 Utilization of Resources

**Table 7: Waste related to utilization of resources.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Availability of trucks. | Optimize the utilization of trucks. | Optimize load capacity. | Utilization of drivers and fleet. |
| Repair of trucks during daytime reduces availability. | | | High percentage of costs relate to labour. |
| High cost of extra personnel. | | | |

Low utilization of available resources, such as trucks and drivers, are mentioned as a form of waste. Hauler Operational Manager 1 exemplifies that they saved money when they rejuvenated their truck fleet thanks to higher availability of the trucks, lower reparation costs et cetera.

For Hauler Operational Manager 3 it is important with high availability of the trucks. A form of waste is when the trucks are standing still during the day because of necessary reparations. It should be valuable for him if the repairs could be performed during a night shift and thereby increase the availability of the trucks. The proper staffing is important for Hauler Operational Manager 1. People with no tasks are inefficient and an uneven flow of goods forces the company to take in extra hired staff which is another form of waste according to Hauler Operational Manager 1. Extra staff hired causes a lot of extra costs say Hauler Operational Manager 3 and exemplifies with higher costs for damages on the trucks et cetera.

Lean Expert 2 argues that it is important to use the truck in an optimal way. He exemplifies with an experience from the field were the truck and trailer did not always fit together (height, aerodynamic aspects et cetera).

Another aspect of waste associated with the truck is the capacity utilization. Business Analyst 1 argues that a significant number of the trucks running on Autobahn in Germany run empty if the fill rate is re-calculated to full trucks. Much of the problem with capacity utilization relates to insufficient planning.

Volvo Manager 1 argues that both the utilization of the drivers and the fleet is important for a hauler. Volvo Manager 2 says that approximately 30 percent of the costs in a hauler’s operations relate to labour costs.

### 4.1.4 Loading and Unloading Process

**Table 8: Waste related to the loading and unloading process.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Waiting time in the harbour. | Loading and unloading causes waste. | Loading and unloading large form of waste. | No technical support for the driver to load and unload. |
| | Unclear responsibilities for securing the goods. | Terminal work optimized for internal efficiency. | |
| | Lack of communication. | Attitude towards drivers. | |
| | Defects on the goods when loading and unloading. | Future security perspective. | |
| | Handling of goods at terminals inefficient. | Opening hours of shipper and receiver. | |
| | Design of trailers. | | |

Hauler Operational Manager 1 says that a lot of waiting time is associated with the loading and unloading process. He exemplifies with transport assignments to the Port of Gothenburg were drivers usually has to wait for unloading and loading the goods.

The loading process is linked to problems with securing the goods according to Lean Expert 2. This often occurs because the loading, of for example a trailer, often is performed by someone else than the driver. Lean Expert 2 means that this causes problems for the drivers as this area is not their responsibility in the first case. One example of the problem is the lack of communication how the goods should be secured. Another example is the narrow view of each actor’s field of responsibilities instead of a view of the whole chain of activities. Lean Expert 5 mentions the risk of defects on the goods when loading and unloading the goods and also defects that can occur during the transport.

Lean Expert 3 also means that a lot can be improved in the goods handling at the terminals. He exemplifies with loading and unloading of goods at some terminals in Japan where the trucks are loaded from the side of the trucks. Lean Expert 3 argues that for a distributor it could be interesting to study how the load process could be improved so goods that should be unloaded first should be loaded to the truck last. Lean Expert 5 describes the same problem for drivers in Japan but the process is even more disciplined; the driver has only access to the slot time within a certain time slot and the access is controlled by a system unlocking and locking the dock for the driver.

The process of loading and unloading the truck is a large form of waste according to Business Analyst 1. The whole procedure of loading and unloading the trucks are often designed from the terminals point of view rather than quickly load and unload the truck. The attitudes towards the drivers are sometimes disrespectful and long waiting times and low prioritizing is not uncommon. The opening hours of the sender and receiver are another problem for utilizing the fleet efficiently according to Business Analyst 1. Business Analyst 2 discusses the loading and unloading process from a security perspective. Today there is usually no waste with waiting times when entering a terminal. However, Business Analyst 2 argues that this could change in the future with higher demand of security controls when entering a terminal facility. Another aspect of the loading and unloading process is that the driver seldom knows exactly were to unload, if the arrival should be reported in the reception before or after loading and such according to Business Analyst 2. Associated problems are slot times used at larger terminals such as Volvo Logistics in Arendal were the driver must be exactly in time to be able to unload the goods. Volvo Manager 2 mentions that the drivers usually load the trucks themselves and there is usually no technical support were to place the goods to optimize the loading process.

### 4.1.5 Administrative Processes and Pricing Model

**Table 9: Waste associated with administrative processes and pricing model.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Time used but not charged. | Functional organization. | Old fashioned routines. | Inefficient administrative processes. |
| Fixed price model and waiting time in traffic. | Poor integration of IT systems. | A lot of manual paperwork. | Usage of old equipment. |
| Assignments with negative financial results. | | | Wrong payment for assignments. |

For Hauler Operational Manager 1 one form of waste is time used which can not be charged to the customer. Depending on the price model for a specific contract it is possible that all time used for a specific transport assignment can not be charged to the customer. Hauler Operational Manager 1 exemplifies one of their distribution routes were the price is fixed plus a variable fee for the number of stops for unloading of goods they do. In case of traffic problems and such they can not charge the customer for the extra time used. Hauler Operational Manager 3 mentions the problem in his business with haulers that accept assignments they make losses on rather than letting the trucks standing still. This is, in his opinion, a form of waste.

Lean Expert 3 discusses a number of issues in the administrative processes causing waste. He mentions the functional organization of the administration instead of organizing around the value flow as one problem. One cause of the unnecessary work in administrative processes is the poor integration of information systems according to Lean Expert 3.

Administrative processes, such as the order-to-cash cycle, are another source of waste. Business Analyst 1 means that administrative processes often are handled in an old fashioned way. A lot of the communication is handled by phone or fax and the work involve a lot of paperwork were the drivers must visit the office regularly to collect and leave papers. Business Analyst 1 gives several examples from his experience were administrative processes have been streamlined. According to Business Analyst 1 a success factor is the involvement of the customer, both shipper and receiver, to eliminate waste.

Volvo Manager 3 discusses the inefficient way administrative processes work in a hauler's administrative processes. Volvo Manager 2 discusses the problem with old systems that are used in the administrative processes. He exemplifies with the early versions of the digital tachograph that are still in use at many haulers. It can takes up to 20 minutes to upload the data from the tachograph to the business system. This task is performed once a day by each driver resulting in a lot of wasted time according to Volvo Manager 2.

Volvo Manager 2 argues that he believe that a common problem for many haulers is that they are paid incorrectly. He exemplifies with a haulers terminal in Borås were the customer is charged for volume and weight. The hauler started to measure both volume and weight and noticed that all customers cheated more or less. After the controls they could charge the correct price and customer stopped cheating.

### 4.1.6 Vehicles and Drivers

**Table 10: Waste related to vehicles and drivers**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Defects on the fleet. | Educational level of the drivers. | [Not discussed] | Right engine, drive line et cetera. |
| Cost of tires. | Defects on the transported goods. | | Right vehicle for right assignment. |
| Drivers' behaviour. | | | |
| Right specified vehicles. | | | |
| Right fuel. | | | |

A common type of waste mentioned by the hauler's managers is defects on the fleet and other equipment. Hauler Operational Manager 2 mentions a two weeks education at the insurance company "If" in Norway he participated in. He used the experience from the education and designed an education programme for his drivers. It resulted in significant lowered yearly costs of defects on the vehicles. Hauler Operational Manager 1 says that the most obvious form of waste is the high cost of defects on the trucks due to collisions on the road or other type of collisions with loading docks et cetera. Hauler Operational Manager 1 exemplifies with year 2007 when the cost of defects on the fleet which was in parity with the net profit.

Another large type of cost is the cost of tires. Hauler Operational Manager 3 exemplifies with one type of traffic assignments they perform and that the cost is very depending on what type of transport that is performed.

Hauler Operational Manager 2 exemplifies from his experience and argues that two parameters are important: driver's behaviour and that the right vehicle is used for the right assignment. Hauler Operational Manager 2 also discuss, in his opinion catastrophic, additive in the fuel such as Rapeseed-Oil Methyl Ester (RME). This causes a lot of waste such as higher fuel consumption, lower engine effect, more oil changes et cetera according to Hauler Operational Manager 2.

Lean Expert 2 exemplifies from his experience in the haulage business that drivers with low level of education could handle much of the work. But if something went wrong the drivers could not handle the situation themselves causing a lot of problem for the company.

Volvo Manager 2 argues that trucks which are not maintained properly causes a lot of unnecessary waste. He mentions the importance of choosing right engine, drive line and what kind of application the truck is used for.

## *4.2 Identification of Waste*

The following section presents a part of the empirical study which concerns identification of waste in haulers' operations. Throughout the empirical study different ways for identification of waste were found. In the following sections areas concerning process mapping, data and general tools, communications and observation, and education are presented.

### 4.2.1 Process Mapping

**Table 11: Process mapping to identify waste.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| [Not discussed] | Adapt VSM. | VSM is an excellent tool to identify waste. | VSM discovers problems with time, cost and quality. |
| | Important to involve everyone in the value flow. | Process mapping reveals unnecessary buffers, in-balances and delays. | VSM helps to find bottlenecks. |
| | Important to handle small problems that disturb processes and workers. | Adapt VSM. | |
| | VSM facilitates a good overview of the business. | | |

Several of the interviewees mentioned process mapping as a good tool to identify waste in hauler's operation. Lean Expert 2 describes VSM as a good tool to achieve a common view of the business for everybody involved. This can create a more constructive dialogue about the problem areas.

Lean Expert 3 also says that VSM would work very well and he suggests including video analysis, interviews, and observations to the mapping. He thinks it is important to include everybody within the value flow, for example in continuous improvement teams. Lean Expert 4 also mentions VSM as a good tool to identify waste. She says that it is important to map the big picture and at the same time look into the small things that disturb processes and workers. The small things can be to identify variations and hassle between the employees.

Business Analyst 3 also talks about process mapping as an excellent tool to identify waste. Business Analyst 3 thinks it is a good way to find unnecessary buffers, in-balances and delays. He says it is good to map the entire value flow and then choose important sub processes to assess on a more detailed level, for example transport flows. Business Analyst 3 further thinks much can be borrowed from the lean philosophy and production logistics. He mentions VSM as a good way to identify waste and he thinks lean can be twisted and modified to suit the identification of waste in haulers' operations.

Volvo Manager 1 describes VSM as a way to discover problem. He also says that VSM can help to reveal bottle necks in the value flow.

### 4.2.2 Data and General Tools

**Table 12: Data and general tools to identify waste.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| System for accident reporting too time consuming. | Spaghetti- and pareto diagrams are useful tools. | ISO management system is a general tool to identify waste. | Kaizen can be a good tool |
| Route optimization systems are to complex. | Virtual tools can be helpful. | | |
| Fuel consumption follow up needs a supporting tool. | Root-cause analysis is good to reveal and solve problem. | | |
| ISO management system is a general tool to identify waste. | Alert system is a way to identify waste. | | |

The support from computers and other general tools to identify waste have been mentioned from several of the interviewees. Hauler Operational Manager 1 describes a system for incident- and accident reporting where it takes five to ten minutes to report one single incident or accident. Hauler Operational Manager 1 says that a driver has between five or ten incidents per day and it would require hiring more personnel just to report these incidents into the system. He would prefer a system where every report takes five to ten seconds. Hauler Operational Manager 1 says that he is not that interested in acquiring information about single incidents from the system but rather seeing trends and locations of incidents. Hauler Operational Manager 1 continues to tell that they have tried different systems to optimize their routes but they have been to complex with to many parameters. They were not satisfied with the result they achieved.

Hauler Operational Manager 2 says that a system has to be used to follow up fuel consumption. Hauler Operational Manager 3 tells about a system they implemented where they assembled a ring on the fuel cap, which registers when the cars are being filled.

Hauler Operational Manager 1 says that they worked with ISO management systems for environment, personnel etc. He thinks those can be used to identify waste. Hauler Operational

Manager 1 also says they receive data from their supporting financial system and insurance company, which are very useful to identify waste.

Lean Expert 5 describes that many tools can identify waste, but one must find the most effective one. A spaghetti diagram would not be very useful if you analyse transports within Volvo Group. Volvo Group has plants in Umeå, Gothenburg and Genth but there is also a political discussion that has to be taken into consideration. A spaghetti diagram would not be fair in this situation. It is very important to find tools to identify waste suited for your specific business. Other general tools can be Pareto diagram, virtual tools and cost-models. Lean Expert 5 continues to say that it is very important to translate the data into something that is understandable. Lean Expert 4 talks about other general tools such as alert system, built-in-quality and root cause analysis to be able to identify waste.

Business Analyst 1 also mentions ISO management systems as a good way to identify waste. When he worked at a hauler they created a guide with improvements for the invoice process.

Volvo Manager 2 says that there is no general tool box, but that he can imagine kaizen event to be a good tool.

### 4.2.3 Communication and Observations

**Table 13: Communication and observation to identify waste.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| A system to identify trends and variations in driver's time et cetera. | Diaries for the driver to fill in. | Talk to the CEO to get overview. | Make sure the observation match with the reality by communication. |
| | Standardized language usage. | Go with the truck to observe. | Keep the observation simple and pragmatic. |
| | Use paper, pen and post-it notes when observing. | | |
| | Standard protocol to fill in when observing. | | |
| | Go with the truck to observe. | | |
| | Get an overview of the different roles at the hauler. | | |

Lean Expert 1 thinks a good way to observe is to follow the truck driver in his daily work. In this way you can do a waste study of the driver. Lean Expert 2 says it is very important to get an overview of the different roles at the hauler, for example traffic control and driver. This is also important for the employees at the hauler. A good way to do this can be to let the drivers sit with the traffic control for one day, this will raise the understanding of the different roles.

Lean Expert 3 thinks one way to identify waste can be to introduce diaries for the drivers where they can fill in what is working well and what is not. This can be done manual or electronic. Lean Expert 3 says that differentiating between the activities is necessary so the drivers can ask themselves what they are doing right now. This will make it easy to assess what is waste and what is not. Lean Expert 4 thinks a standardized language use and a methodology for problem solving is very important to distinguish what is waste and what is not. Lean Expert 4 also thinks it is very important with feedback from both the shipper and the receiver to identify waste.

Lean Expert 5 says it is very useful with a piece of paper, a pen and post-it notes when observing but also argues for the importance of more computerized tools. He thinks observation protocols for the different activities can be very helpful.

Business Analyst 3 thinks it is important to talk with the CEO to find out what is working and what is not. This will get a good awareness of the business situation and the big picture. Business Analyst 3 further thinks the best source to identify waste is the one who carry out the work, the driver. It is also much easier to change behaviour, if the one doing the actual work is involved in doing the improvement suggestions.

Volvo Manager 1 argues for the importance of interviews and observations. He thinks it is important to first do an initial analysis to show improvement potential and it is very important that this is done in a simple and pragmatic way. Volvo Manager 1 mentions a computer tool for observation, but says that this can create distance between you and the persons not working with VSM everyday. Volvo Manager 1 says that one of the most important things when doing observation is to ensure that the observation match the reality before starting to make changes otherwise this can be a dangerous trap.

Hauler Operational Manager 1 says that he would like to have a system that shows the driver's time and cost for damages on the vehicle. This can be a way to identify trends and variations.

### 4.2.4 Education

**Table 14: Education to identify waste.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Education in eco-driving. | Clear aim to get education in right direction. | Educate personnel to write variations reports. | Organizational Development is important. |
| | Organizational Development is important. | | KPI education is useful. |
| | Create and educate teams. | | Balanced Scorecard education is useful. |

Hauler Operational Manager 3 mentions that they carried out eco-driving education with some of their drivers. He says that many of the drivers felt that this education was unnecessary. The drivers think that this is their competence area and that they already know it.

Lean Expert 4 argues for the importance to find tools suited for ones own business. A way to visualize waste is to use improvement teams. This teams need to receive proper education. Lean Expert 4 talks about the importance to set a clear aim. The management has to be involved and the objectives has to be broken down into goals on a more operational level. Some kind of Operational Development (OD) methodology can be used, which is good in order to reveal small and big steps towards the objectives.

Volvo Manager 2 also talks about OD. He stresses that one must find motivations to everybody that are affected from the changes/improvements. He says that OD is a good way to gather and coordinate the personnel. Other tools can be KPIs and Balanced Scorecard.

Business Analyst 1 tells that a part of the work with ISO management systems was to educate the personnel, for example the drivers and the administrative personnel to write deviations reports.

## *4.3 Visualization of Identified Waste*

The following section presents the part of the empirical study that concerns visualization of waste in haulers' operations. Throughout the empirical study different ways for visualization of waste were found. In the following sections the topics process mapping, workshops and meetings, visualization tools and adapt VSM will be presented.

### 4.3.1 Process Mapping

**Table 15: Process mapping to visualize waste.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Mark the waste with red squares during process mapping. | Paper and post-it notes are good tools to visualize waste during process mapping. | Paper and pen are good tools to visualize waste during process mapping.<br><br>Time taking is a good tool to visualize waste during process mapping. | [Not discussed] |

Hauler Operational Manager 1 mentions that an auditor was auditing their processes at the hauler he worked for some years ago. The auditor suggested that they should draw their processes, and mark the unnecessary processes with red squares. Hauler Operational Manager 1 says that this is a very good way to illustrate waste in the business.

Business Analyst 3 says that he been doing a process mapping with paper and pen at a company and it went well. He thinks paper and pen are good tools to visualize waste. He points out the importance to be structured. He says that half ways during the process mapping they figured out that it would have been good to measure time for the processes, in order to visualize the waste in a better way. He says a suggestion is to measure which processes that takes equal time every time, and which that is more inconsistent. In this way you can compare processes in order to visualize waste.

Lean Expert 1 says a tip is to use post-it notes and papers when doing a process map instead of using the computer.

### 4.3.2 Workshops and Meetings

**Table 16: Workshops and meetings to visualize waste.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Team meetings. | Work shops to get the same vision. | [Not discussed] | Set up scenarios to visualize. |
| Presentations so everybody involved get a clear picture. | Daily meetings. | | |

Hauler Operational Manager 1 explains that they have team meetings where they go through how large the profit was for a certain time period. He says that this is one way to visualize how they are performing. He further says that other types of waste can be harder to visualize. An example is how hard it is to see if they have a half time employee to much. In this case he follows his feelings more than trying to visualize it.

Hauler Operational Manager 2 says that they are doing presentations for their employees to visualize different measures, an example is how much money the drivers drove in last month compared to their wages. He says that this is the part the drivers are most interested in and he always start with this to get everybody’s attention. He also shows them fuel consumption and wear to tyres. During the meetings they also go through incidents and accidents. It is very important that the driver himself get the opportunity to explain what happened, and why.

Lean Expert 4 says that it is crucial that everybody involved have the same vision to get a discussion. In one of her previous projects many companies were involved. They arranged workshops for employees from the different companies in order to get everybody involved an overall picture of the value flow. This led to a better decision making base. Lean Expert 4 describes that in the latest years, daily meeting have become more and more popular. She points out the importance of keeping the quality of the meetings high. A half-hour meeting should not include problem solving, it should just identify and visualize problem.

Volvo Manager 2 describes his experience from visualizing. He has previously been working with illustrating how technology can affect decision making. He says it is good to visualize how technology works through putting it into different scenarios. Volvo Manager 2 thinks the trend to visualize in this way is most usual in the military. He says that there is an American organization within the military that are working with role plays. They have begun looking into the transport business and autonomous vehicles.

### 4.3.3 Visualization Tools

**Table 17: Visualization tools to visualize waste.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Drivers hand book to visualize the work. | Pins in different colours to visualize orders etc. | Benchmarking to visualize waste. | LCD screens to show trends. |
| | 7 parameters (P, Q, E etc.). | Methods such as PROPS. | |
| | Visualize the aim on a relevant level. | | |
| | Put together waste on group level. | | |
| | Whiteboards. | | |

Hauler Operational Manager 1 says that they have started to create a hand book for their tobacco distribution. The hand book will contain information when the work day begin, description where to load and where to unload, how breaks are scheduled etc. They will also create productivity measures to describe how much there have to be done in one day. In this way they will be able to visualize if there are any waste. Hauler Operational Manager 1 says that the aim in the future is to create this sort of hand book for the traffic control and administration. He mentions a hand book for the drivers they tried to use, but updates had to be done too often and it resulted in to much work. Hauler Operational Manager 2 also talks about the hand book they are using. It contains work descriptions for the drivers.

Lean Expert 1 gives one example how to visualize where you use seven parameters; a green cross for environment, a Q for quality, an E for economy, a S for security etc. Every letter or cross is filled with 31 squares numbered from 1 to 31 which will be marked with red, yellow or green. If, for example, there have been no accidents one day that day is green, if it was near to be an accident that day is yellow and if there have been an accident the square symbolizing this day is red. This is a good way to visualize and gives direct feedback.

Lean Expert 2 says that whiteboard is useful to visualize waste, the waste can be visualized on team-level. It is important that the workers are involved to find the waste and Lean Expert 2 thinks everybody is interesting in improving their own situation. Lean Expert 2 also says it is important to have routines for stress, ergonomics, quality and security. Often they do an overall picture for the routines and then a description for the processes. These will be used to support, and for new employees.

Lean Expert 5 and Lean Expert 1 is talking about the seven parameters; S, E, Q etc and says that they are used to show trends and deviations from the aim. Lean Expert 5 point out the importance to visualize the aim on a relevant level. It is not that relevant to show the plant aim to the workers which assembly the tyres. It is better to show tyres delivered in time.

Volvo Manager 2 says one good way to visualize waste is to benchmark. There are also other good tools to visualize. For example projects support like PROPS, which help and support you during a project.

Volvo Manager 3 says that one department have LCD displays to show trends on bugs during programming. He thinks this is a very good way to visualize.

### 4.3.4 Adapt Value Stream Mapping

**Table 18: Adapt Value Stream Mapping to visualize waste.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| [Not discussed] | Good tool to visualize the overall picture.<br>Define what is adding value to the customer.<br>Good tool to prioritize which activities to improve.<br>Do a VSM in reality as soon as possible. | Reliable and tested tool to visualize the overall picture.<br>Define what is adding value to the customer. | Present VSM in a pedagogic way. |

Lean Expert 2 talks about the benefits of VSM and mentions the opportunity to get a really good overall view of the business. It is a good tool for the employees to see which part of the value flow they are working in. The ambition with VSM has to be to keep it simple. Lean Expert 2 thinks it is very important to try VSM in the reality as early as possible to learn by doing.

Lean Expert 4 says that a positive thing with VSM is the easy way to visualize the business. Lean Expert 4 describes that it is only a snapshot of reality but that this moment is as good as any other moment. VSM gives a concrete picture and something to work further with. One thing to take in consideration is that VSM often needs to be complemented. If you for example mapped a value flow, and back at the office you see that you are missing something you have to turn back. Lean Expert 4 mentions the importance to define what is adding value to the customers in order to do a proper VSM. This can differ in the transportation business compared to the production environment.

Lean Expert 5 thinks VSM is a good tool to prioritize. During a VSM one often find too many things that can be improved and then he usually looks at two things when he prioritizes. Partly how easy it is to implement and partly how big difference it will make. One other benefit is the good overall picture it will provide, and most important, that everybody got the same picture. One negative aspect can be that too many improvement suggestions will be found and this will lead to frustration while you can't fix everything directly.

Lean Expert 5 argues that every VSM you do, you need to adapt the method. If you use VSM in the transportation business you have to do even more adaptations. Transport maybe needs to be a value adding activity for the customer compared to production where transport is waste. But Lean Expert 5 says that he thinks we should keep the VSM as similar to the "production-VSM" as possible and the changes don't have to be too big. He says he used VSM to many different things such as mapping order to cash, environmental aspects and ergonomic aspects. He also used VSM to map the energy usage and then they only added one more row in the process square.

Business Analyst 3 thinks an advantage when using VSM is that it's a tested and reliable method. People have often heard about VSM and there is much literature written about it. Business Analyst 3 think much waste can be find by following an order throughout a company. To be able to use VSM in transportation some adaptations have to be done and what brings value to the customer has to be defined.

Volvo Manager 3 point out the importance to present VSM in a pedagogic way so everybody understands it.

## *4.4 Measuring the Identified Waste*

The following section presents the part of the empirical study that concerns measuring of the identified waste in haulers' operations. Throughout the empirical study different possibilities to measure waste were found. In the following sections measuring operations, visualisation of measurements and Key Performance Indicators in haulers' operations will be presented.

### 4.4.1 Measuring Operations

**Table 19: Measuring operations.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Bottom line result is important. | Keep It Short and Simple. | [Not discussed] | Measure in multiple dimensions. |
| Operational parameters. | Measure what can be changed. | | |
| Monthly reports to follow up. | Mind set and philosophy. | | |
| | Measure in multiple dimensions. | | |
| | Relation between the measures. | | |

Hauler Operational Manager 1 says that the bottom line result is the most important parameter to measure. Other aspects that could be measured are personnel, vehicle, fuel and defects. At his company they use monthly reports to summarize the performance of the company. The monthly report is useful to identify deviation and to follow up the performance.

Lean Expert 1 suggests that it is important to remember the "Keep It Short and Simple" rule to work efficient with measurement. Lean Expert 1 also stresses the importance of working with measurement that the personnel can affect. He exemplifies with the filling rate of the truck which the drivers barely can affect.

Lean Expert 2 argues that measures are important but that the mind set of people and the philosophy are more important. Lean Expert 2 means that philosophy comes first, then principles and last methods. Lean Expert 2 draw parallels to his work as a lean consultant were they start with helping the client to define their philosophy, values and principles before they start to measure different parameters. There are different aspects of measuring value and results. One dimension can be satisfaction of the employees. A high satisfaction index will attract good drivers which add value to the company. Lean Expert 2 exemplifies with an example from a Toyota retailer. They decreased the working hours from 8 hours to 6 hours without decreasing the payment. They expanded from one to two shifts and could therefore have open longer hours. This also attracted the best mechanicals and gave the company a very good reputation.

Lean Expert 5 says that the relation between measures is important. He exemplifies with increasing environmental performance often leads to increased cost at the same time. Lean Expert 5 means that it is not possible to optimize all parameters at the same time.

Volvo Manager 2 describes a project when he worked with a Total Customer Solution project. They defined goals in four dimensions: customer; competitive position; competence and financial. Then they defined vision, project objective, KPIs and fulfilment for each dimension.

### 4.4.2 Visualization of Measurement

**Table 20: Visualization of measurement.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| Presentations. | PowerPoint. | PowerPoint. | [Not discussed] |
| Meetings. | Red/Yellow/Green figures. | Whiteboard. | |
| | Graphs. | Graphs. | |
| | Seven parameter figures. | Measure in SEK instead of litre etc. | |
| | KPIs are the basis for root-cause analysis | | |

Hauler Operational Manager 2 says that they regularly compile presentations to visualize measures such as income per driver. He says that the drivers are most interested in this type of information.

Lean Expert 5 says that when you work as a consultant you will become a PowerPoint expert and a lot of the work is visualized through PowerPoint presentations. He suggests that using red, yellow or green figures to indicate performance makes it easy to understand. Lean Expert 5 says that KPIs should drive the improvements in the organisation. He exemplifies with if an organisation measure delivery precision and they achieve 100 percent, they measure it the wrong way. Lean Expert 5 also suggests that KPIs are the basis for root-cause analysis to reveal the underlying problem.

Business Analyst 1 tells that he works with PowerPoint and whiteboards to communicate and visualise measurements. He suggests that working with graphs and figures is to prefer over tables and complicated data sets. Another suggestion from Business Analyst 1 is to translate units to SEK rather than presenting for example litres. He also argues that the usage of percentage can be difficult to understand for some people.

### 4.4.3 Key Performance Indicators in Haulers' Operations

**Table 21: Key Performance Indicators in haulers' operations.**

| Hauler Operational Manager | Lean Expert | Business Analyst | Volvo Manager |
|---|---|---|---|
| General KPIs related to personnel. | Delivery precision. | Km production / vehicle. | Uptime. |
| General KPIs related to vehicles. | Employee satisfaction. | Km production total. | Cost of poor utilization. |
| Fuel consumption. | Value added time in relation to lead time. | Revenue / Km. | Cost of defects. |
| Cost of damaged goods and vehicles. | Seven parameters (S, Q, E et cetera). | Vehicle cost / Km. | Revenue and cost / Km. |
| | Capacity utilization. | Personnel cost / Km. | Fuel consumption / Km. |
| | | Lead time. | Driver behaviour. |

Hauler Operational Manager 1 says that measuring KPIs related to personnel, vehicles, fuel consumption and cost of defects for goods and vehicles are most important to him.

Lean Expert 2 suggests that delivery precision is a good KPI. He discuss that different KPIs are interesting for different stakeholders. The customer interface could be measured by service delivered and a company internal KPI could be employee satisfaction. Lean Expert 2 says that it is important to take both the shipper and receivers perspective to create a win-win situation. Lean Expert 2 means it could be interesting to look on the value flow analysis with representatives from the shipper, transporter and receiver to optimize the whole flow.

Lean Expert 5 says that value added time in relation to the total lead time is interesting. He also states that it is important to have a strict definition what is value adding activities. Lean Expert 5 means that frequency studies can be useful to see how many trucks run empty and that all empty running trucks are waste. However this studies must be statistical correct with enough data to be valid according to Lean Expert 5. He also says that other KPIs that could be useful are capacity utilisation and the seven parameters Security, Quality, Environmental, et cetera.

Business Analyst 1 is involved as a board member in a couple of haulers and has worked with KPIs. He suggests a number of KPIs which are useful for a hauler: kilometre produced per vehicle, kilometre produced total, revenue per kilometre, vehicle cost per kilometre (including cost for tire, repairs, et cetera – fuel can be included or excluded), personnel cost per kilometre. Business Analyst 1 concludes that it is important to measure per kilometre or per hour. He also stresses the importance of using a set of KPIs to measure performance. KPIs are useful when monitoring over time. Equipment such as DynaFleet is very useful for collecting data.

Business Analyst 3 suggests that useful KPIs are fill rate, empty run kilometres, fuel consumption, lead time, missed deliveries and defect goods.

Volvo Manager 1 suggests that general KPIs are important. He also says that benchmarking against other companies is good. Volvo Manager 1 suggests the procedure of first defining the goal, measure and then follows up. To collect KPIs for comparison of different industry organisations can be useful. Volvo Manager 1 suggest that uptime, cost of poor utilisation, defects, utilisation of drivers and vehicles, revenue and cost per kilometre, fuel consumption and driver behaviour are interesting KPIs.

## 4.5 Observations

When doing the Hauler Operational Managers interviews, observations were also conducted. The observations were made on an operational level to acquire deeper knowledge of the business, to get a better overview and to understand how different processes interact with each other. Observations in the administration, traffic control and going with the truck was done. The observations gave insight of the different operations in the order to cash flow and in the goods flow.

# 5 Analysis

*The analysis was based on the theory study and the findings in the empirical study. The analytic work process is presented and followed by the analysis in four sections corresponding to each of the four research questions presented in the introduction chapter.*

## 5.1 Analytic Work Process

The analytic work process in Figure 8 gives an overview of how the analysis has been conducted. The theory study supports the framework for data collection, the empirical data collection, the analysis and the modelling. The empirical data collection, analysis and the creation of the methodology parts aims to answer RQ 1, RQ 2, RQ 3 and RQ 4. The methodology has then been tested and validated.

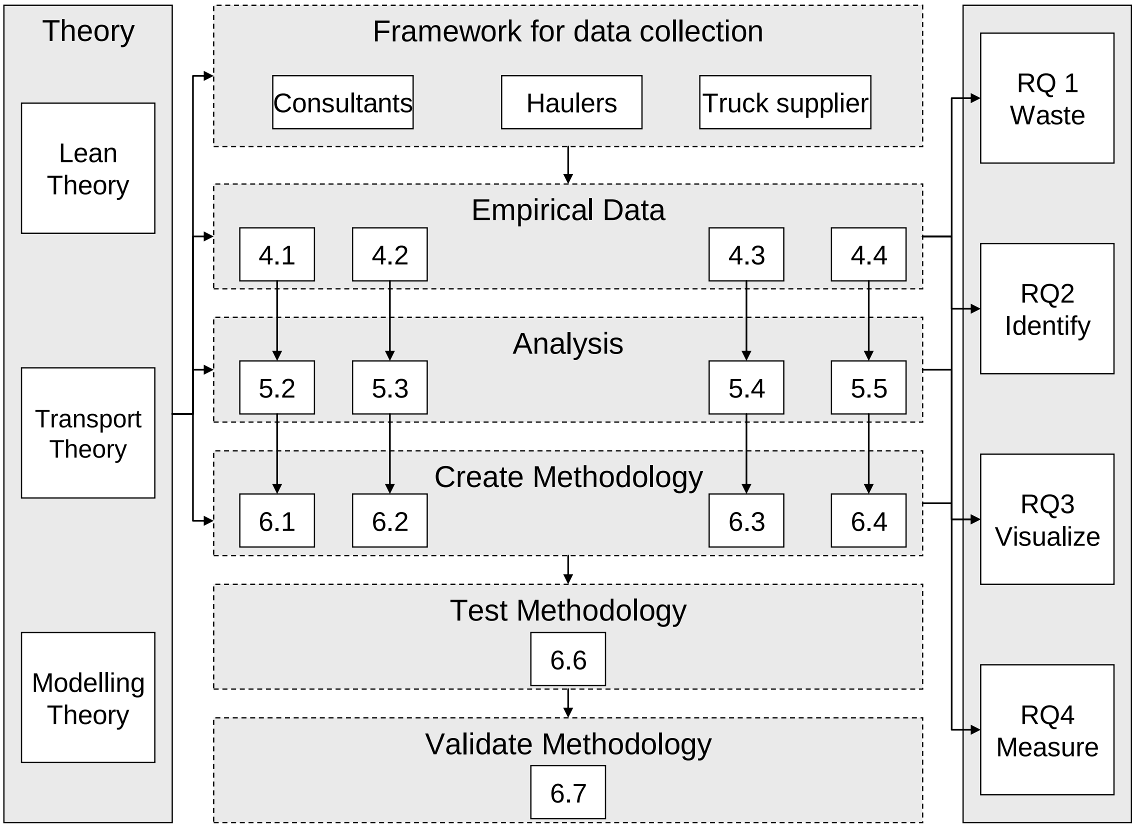


**Figure 8: Analytic work process.**

## 5.2 Waste in Haulers' Operations

The theory suggests a classification of waste, in production environment, in the eight categories overproduction, waiting, unnecessary transport or conveyance, overprocessing or incorrect processing, excess inventory, unnecessary movement, defects and unused employee creativity (Liker, 2004).

The definition of waste for each category can be translated to the transport business. Table 22 suggests how the categories for waste in haulers' operations can be defined. The definitions are adopted from Table 1, which are the definitions used in a production setting.

**Table 22: Definition of waste in haulers' operations.**

| Waste | Description |
|---|---|
| Overproduction | Transporting goods for which there are no orders, which generates such waste as overstaffing and storage and extra transportation costs. |
| Waiting (time on hand) | Employees having to stand around waiting for the next process step, such as loading and unloading, or just having no work because of lack of orders, processing delays, equipment downtime, and capacity bottlenecks. |
| Unnecessary transport or conveyance | Inefficient transport, moving goods into or out of storage or between processes. |
| Overprocessing or incorrect processing | Taking unneeded steps to move the goods. Inefficient processing due to poor equipment and process design, causing unnecessary motion and producing defects. Waste is generated when providing higher-quality delivery than is necessary. |
| Excess inventory | Excess raw material or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay. Also, extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times. |
| Unnecessary movement | Any wasted motion employees have to perform during the course of their work, such as looking for, reaching for, or stacking goods, equipment, papers etc. Also walking is waste. |
| Defects | Production of defective goods or correction. Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort. |
| Unused employee creativity | Losing time, ideas, skills, improvements, and learning opportunity by not engaging or listening to your employees. |

The model of waste in the transport business, as suggested in Table 22, can be applied to the data collected in the interviews and observations presented in chapter four. The results derived are listed in Table 23.

**Table 23: Model of waste in the transport business applied on empirical data.**

| Form of waste | Example from interviews and observation |
|---|---|
| Overproduction | Route optimization. |
| | Information flow between traffic control and driver. |
| | Old fashioned routines in administrative processes. |
| | Assignments with negative financial result. |
| | Time used but not charged. |
| Waiting (time on hand) | Dependent upon ferry schedules and driving hours. |
| | Future security perspective. |
| | Opening hours of shipper and receiver. |
| | Functional organization causing unnecessary waiting time in administrative processes. |
| | Fixed price model and waiting time in traffic. |

| Form of waste | Example from interviews and observation |
|---|---|
| Unnecessary transport or conveyance | Inefficient handling of goods at terminals. |
| Overprocessing or incorrect processing | Short term planning horizon. |
| | Lack of IT-support. |
| | Lack of communication. |
| | Difficult to measure and follow up fuel consumption. |
| | Poor utilization of the trucks. |
| | Unclear responsibilities for securing the goods. |
| | Unnecessary high fuel consumption. |
| | High cost of extra personnel. |
| | Poor integration of IT systems in administrative work. |
| | A lot of manual paperwork. |
| | Use of old equipment. |
| Excess inventory | Too many trucks. |
| | Not optimal specification of engine, drive line et cetera. |
| Unnecessary movement | No technical support for the driver to load and unload. |
| | Loading and unloading causes waste. |
| | Poor design of trailers. |
| | Terminal work optimized for internal efficiency. |
| Defects | Defects on the goods when loading and unloading. |
| | Defects on the fleet. |
| | Too high cost of tires. |
| | Not using right fuel. |
| | Defects on the transported goods. |
| Unused employee creativity | Drivers' behaviour such as idle driving. |
| | Attitude towards drivers. |
| | Educational level of the drivers. |

## *5.3 Identification of Waste*

Similarities and differences in ways to identify waste in the empirical study and theory will be discussed in this chapter. In Table 24 the main findings in the theory and the empirical study are compared.

In chapter 5.2 and in Table 23 different waste in the hauler's business is discussed. The waste is divided into 8 types of waste categories. These 8 types of waste can, according to Liker

(2004), be found in production environment but are in the previous chapter translated into the transportation business. The literature advocates different process mapping tools to identify waste such as the SCOR model, object oriented design and VSM but the empirical study indicates the advantages of VSM. The empirical study shows that VSM is an excellent tool to identify waste and reveals a good overview of the business. The advantage of VSM is also stressed by some of the literature. Lasa, et al., (2008) argues that there are other process mapping tools similar to the VSM but those tools neither cover the same framework as VSM nor the same degree of completion of the manufacturing system.

Lean production and VSM for information and material flow in production environment are discussed in the theory chapter. VSM originates from Lean Production (Rother & Shook, 2003) and in the interviews during the empirical study it is indicated that VSM can be adapted to the transportation business. The observations made in the empirical study also point towards an adapted model of VSM in transportation business. Certain changes must be made from VSM in production environment but those can be overcome. The theory also supports lean production and VSM to be tried in other industries. Womack, et al., (1990) argues that lean production is a universal set of management principles that could be applied equally in every industry across the globe. Also Hines, et al., (2004) supports this by mentioning the great example of success stories that exist in the literature.

During the empirical study other tools such as spaghetti diagram, ISO certificates and organizational development are mentioned. Other important aspects found are to involve the management and to do observations in the hauler's operation, e.g. to go with the truck. The literature also means that involving the management in the work is very important and to "walk" the value flow is central. Hines, et al., (2004) addresses that lean is often misunderstood as only a set of methods and techniques to improve the production of a company and suggest that a distinction between the strategic level, "lean thinking" and the operational level "lean production" should be done to fully understand lean as a whole.

**Table 24: Identification of waste.**

| Theory | Empirical Study |
|---|---|
| VSM a good tool to identify waste (Rother & Shook, 2003). | VSM reveals different kinds of waste. |
| Lean can be applied equally in every industry across the globe (Womack, et al., 1994). | Lean can be adapted to the transportation industry. |
| VSM gives a good overview (Rother & Shook, 2003). | VSM facilitates a good overview of the business. |
| There are other process mapping tools but VSM is the best (Lasa, et al., 2008). | VSM excellent tool to identify waste. |
| Process mapping a way to find improvements (Klotz, et al., 2008). | VSM most beneficial process mapping tool. |
| Lean has to be implemented on both a strategically and an operational level (Hines, et al., 2004). | Management must be involved and it is very important to do observations on the "field". |

## 5.4 Visualization of Identified Waste

Similarities and differences in ways to visualize identified waste in the empirical study and theory will be discussed in this chapter. In Table 25 the main findings in the theory and the empirical study will be compared.

During the empirical study, process mapping were mentioned several times as a good tool to visualize identified waste. One of the interviewees said that one way to get a good overview of waste in the value flow is to mark the unnecessary processes with red squares. The empirical study also indicates the benefits of using paper and pen when walking the process to draw a map of the current state to visualize the processes. In VSM theory, paper and pen are also used to draw the value flow. This is used to help you understand the material and information flow (Rother & Shook, 2003).

As discussed in previous chapter one way to identify the waste in the hauler's business is to adapt VSM from lean production. The empirical study indicates that VSM also can be adapted to visualize the identified waste in the hauler's daily operations. When doing a VSM waste can be distinguished from the value adding time and this is a powerful tool to visualize how much waste there is in the processes. The empirical study indicates that it is important to define what is value adding to the customers. The empirical study also indicates the importance of time measuring during process mapping. In the theory Liker (2004) says the exact same. He means that the time from raw material to finished goods is very long and that there are often a lot of waste and to achieve better the waste have to be distinguished from the value adding time. The value adding time is in the literature defined for production environment and some modifications will have to be done for the transport business.

The empirical study shows that group meetings and presentations are good ways to visualize waste. Here whiteboard can be used and also the 7 parameters (E, C, Q etc). The seven parameters can also be used on a more daily basis with the intention to give direct feedback to the employees. Rother & Shook (2003) describes a Value Stream (VS) Manager; he/she will be responsible when the VS cross organizational boundaries. The manager can typically be a person leading group meetings presenting the current state and improvement proposals.

**Table 25: Visualization of identified waste.**

| Theory | Empirical Study |
|---|---|
| Process mapping helps understand material and information flow (Rother & Shook, 2003). | Process mapping is a good tool to visualize waste. |
| Use pen and paper to draw the value flow (Rother & Shook, 2003). | Use paper and pen to visualize the processes. |
| Define value adding time to visualize waste (Liker, 2004). | Define value adding time from customer's point of view. |
| Value Stream Manager (Rother & Shook, 2003). | Group meeting to visualize waste. |

## 5.5 Measuring the Identified Waste

Waste in haulers' operations can be measured in many different ways. One could argue that waste in haulers' operations results in overall lower performance of the company. The theory suggests that KPIs could be used in groups to give an overview of the company's performance. This is supported by one of the interviewees who works with performance measurement in the road transport business.

The different types of waste that exist in a hauler's operations are discussed in chapter 5.2. The theory suggest that a set of 24 KPIs grouped in 6 categories could be used to measure the performance in a hauler's operations. The interviewees in the empirical study suggest a number of KPIs that would be useful to measure performance in the road transport business. These KPIs could be compared with the KPIs suggested in the literature. The results are showed in Table 26.

**Table 26: Theoretical key points and empirical findings**

| KPI category | Empirical findings |
|---|---|
| Cost | Vehicle cost / Km |
| | Personnel cost / Km |
| | Fuel consumption / Km |
| | Cost of poor utilization |
| Operational | Value added time in relation to lead time |
| | Capacity utilization |
| | Km production / vehicle |
| | Km production / total |
| | Uptime |
| Service | Delivery precision |
| | Lead time |
| Compliance | Cost of defects |
| Maintenance | [Not discussed] |
| Environmental | [Not discussed] |
| Not categorized | Employee satisfaction |
| | Revenue and cost / Km |
| | Driver behaviour |
| | Seven parameters (S, Q, E, …) |

The two categories maintenance and environmental are not mentioned by the interviewees in the empirical study. We have found no reason why these two categories are emphasized by the interviewees. One possibility could be that the category maintenance is not distinguished from the operational category and the environmental category is directly linked to the cost of fuel. Another reason could be a prioritization of the categories by the interviewees and therefore the two categories is not mentioned by the interviewees.

To design a measurement system for waste in haulers' operations the waste categories needs to be linked with a measure which then is linked with a KPI. An example of such a connection is showed in Figure 9. The waste "unnecessary high fuel consumption" is grouped in the category "overprocessing or incorrect processing". This category of waste is then linked to the different measures necessary to quantify the waste with a set of categories of KPIs as suggested in the literature.

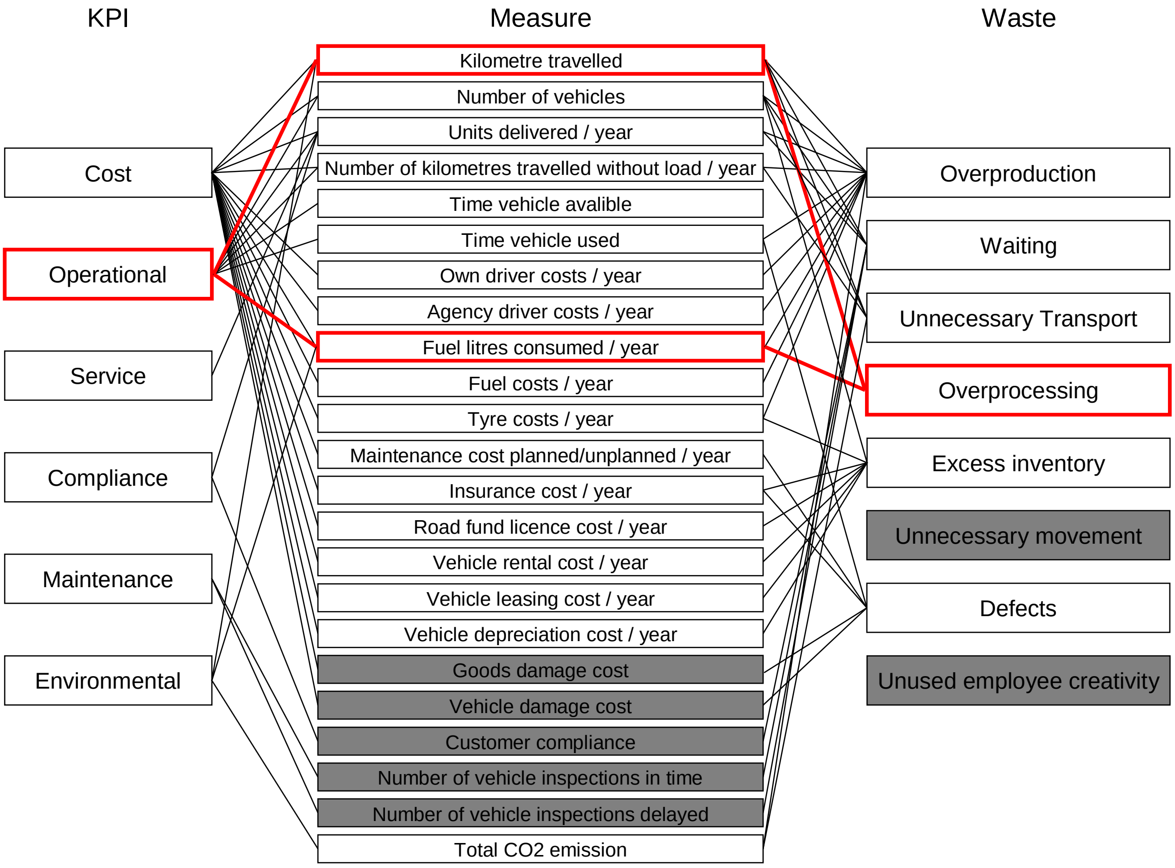


**Figure 9: Schematic connection of waste, measures and KPIs.**

The comparison based on Figure 9 is summarized in Table 27. The comparison shows that the waste category unnecessary movement and unused employee creativity is not covered in the measurement system suggested in the literature and needs to be complemented with additional KPIs.

**Table 27: Waste and KPI measures.**

| Waste category | Definition of waste | KPI measure |
|---|---|---|
| Overproduction | Transport of goods for which there are no orders, which generates such waste as overstaffing and storage and extra transportation costs. | Average driver cost per km<br>Average cost per unit delivered |
| Waiting (time on hand) | Employees that have to stand around waiting for the next process step, such as loading and unloading, or have no work due to lack of orders, processing delays, equipment downtime, and capacity bottlenecks. | Average driver cost per km<br>Average cost per unit delivered<br>Percentage average time utilization |
| Unnecessary transport or conveyance | Inefficient transport, moving goods into or out of storage or between processes. | Average cost per unit delivered |

| Waste category | Definition of waste | KPI measure |
|---|---|---|
| Overprocessing or incorrect processing | Taking unneeded steps to move the goods. Inefficient processing due to poor equipment and process design, causing unnecessary motion and producing defects. Waste is generated when providing higher-quality delivery than is necessary. | Average cost per unit delivered |
| Excess inventory | Excess raw material or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay. Also, extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times. | Total whole vehicle costs<br>Percentage of damages total |
| Unnecessary movement | Any wasted motion employees have to perform during the course of their work, such as looking for, reaching for, or stacking goods, equipment, papers etc. Also walking is waste. | [No measure of unnecessary movement] |
| Defects | Production of defective goods or correction. Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort. | Percentage of damages total |
| Unused employee creativity | Losing time, ideas, skills, improvements, and learning opportunity by not engaging or listening to your employees. | [No measure of unused employee creativity] |

The theory and the empirical study show that using a set of KPIs could be used to measure waste. To enable the collection of data a KPI data collection protocol is designed. This can be found in Appendix E.

# 6 Results

*This chapter presents the results found during this thesis. The results are first presented in four sections corresponding to each of the four research questions presented in the introduction chapter. Then section 6.1-6.4 is concluded in a methodology to identify, visualize and measure waste in section 6.5. The chapter is concluded by a test case and a validation case of the methodology, both conducted at mid-size Swedish haulers.*

## 6.1 Waste in Haulers' Operations

The analysis shows that several types of waste exist in haulers' operations. The various form of waste are categorized in the categories overproduction, waiting, unnecessary transport or conveyance, overprocessing or incorrect processing, excess inventory, unnecessary movement, defects and unused employee creativity. The model is showed in Figure 10 and is adapted from Liker's (2004) model of categorizing waste in production environment.

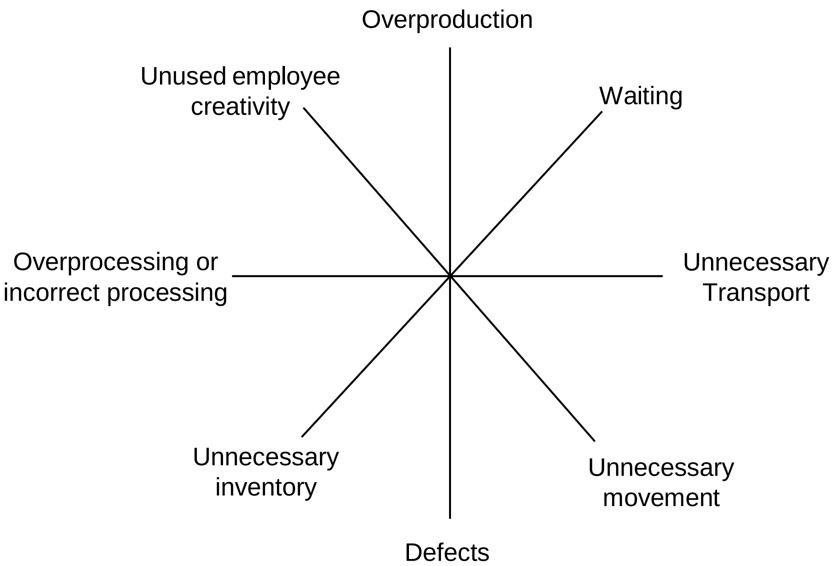


**Figure 10: Waste model.**

The analysis shows that waste in haulers' operations span over all eight categories. A lot of the waste relates to equipment, tools and systems used in the operations such as trucks and IT systems. The category overprocessing or incorrect processing is one of the categories where a lot of waste is found in the empirical study.

One of the waste categories that have a direct impact on the hauler's financial performance is the category defects. Both defects on the transported goods as well as defects on the trucks are grouped in this category. These two types of waste causes huge costs for the haulers and are crucial to keep as small as possible.

Unnecessary movement is also a category of waste which is showed in the analysis to be important. Different aspects of the design of equipment, systems and processes cause unnecessary movements. The analysis shows that some of these movements are relatively short in time span but repeated frequently during the day and therefore have a high impact when accumulated.

Finally the analysis shows that the category unused employee creativity is important. The drivers' behaviour, such as idle driving and driving style, affects factors such as fuel consumption. The general attitude towards drivers and the educational level of the drivers are other important aspects that related to the waste in haulers' operations.

## 6.2 Identification of Waste

To identify the waste in haulers' operation some type of tool has to be used. Concluded from the empirical study and supported by the theory, VSM is the most beneficial one. VSM gives a good overview over the business and it is a simple tool to understand and learn how to use.

To be able to assess the goods flow and to find the waste, the order to cash flow and the processes directly associated and affecting the goods flow must be mapped. This is done more generally and not on the same detailed level as the map of the goods flow. The icons used in the order to cash flow are illustrated in Figure 11. For an example of an order to cash flow, see Appendix H.

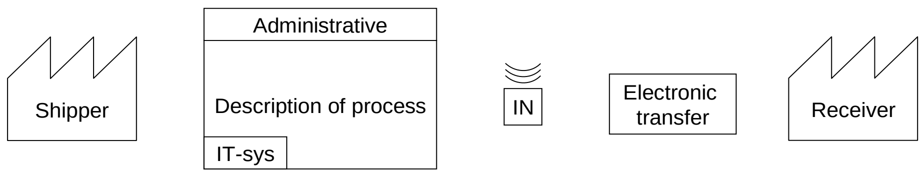


**Figure 11: Icons used when mapping the order to cash process.**

To be able to do a VSM in the goods flow, three different processes are identified. Those are the transport process, the administration process and the handling process. Between the processes there are often time losses, also called buffer time, such as waiting time, standing still et cetera. In Figure 12 the three different process icons are illustrated and also the buffer time icon.

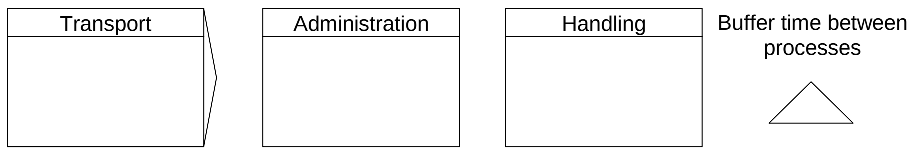


**Figure 12: Processes and buffer time between processes.**

Before starting to do a VSM in the order to cash flow and in the goods flow, observation has to be done at the office. It is important to first talk to the management to involve them and in this way also get a good overview of the business. Next step is to interview the traffic control and the administrative personnel to better understand the business information flow and administrative processes. After this the order to cash flow can be mapped. With this information one could start to go with the truck to observe and map the goods flow on a more detailed level to find waste. See Appendix D for a VSM Observation Protocol used to collect data during the trip. The icons in Figure 12 are used to map the goods flow with support of the VSM Observation Protocol back at the office. Discussion with the driver when following him or her in the daily work will complement the observations.

## 6.3 *Visualization of Identified Waste*

In the empirical study the importance of defining what is value adding time in the value flow for the customer was pointed out. This can be a very powerful tool to visualize how much waste there are in the processes.

In the goods flow there are different processes. Some of them create value for the customer, while some of them do not. To be able to separate those processes from each other, three types have been defined in the goods flow; value adding time, necessary waste and pure waste. These definitions can be directly linked to the processes icons; transport, handling and administration in chapter 6.2. Transport is defined as value adding because this process moves the goods closer from the shipper to the receiver. Administrative and handling are seen as necessary waste, while this is processes that have to be done in order to be able to do the transport. The aim is to minimize the necessary waste to make the processes as efficient as possible. Between the different processes there are time losses; those are pure waste which the aim is to eliminate. Two delimitations in the master's thesis are to exclude fill-rate and route optimization. It could then be assumed that the truck always is fully loaded and drives the optimal route. This will support the definition that transport always is defined as value adding from a customer's point of view.

In traditional improvement work, the focus is often to optimize the value adding processes and this gives limited improvements. There are more potential if one attacks the necessary waste and the pure waste. This is illustrated in Figure 13.

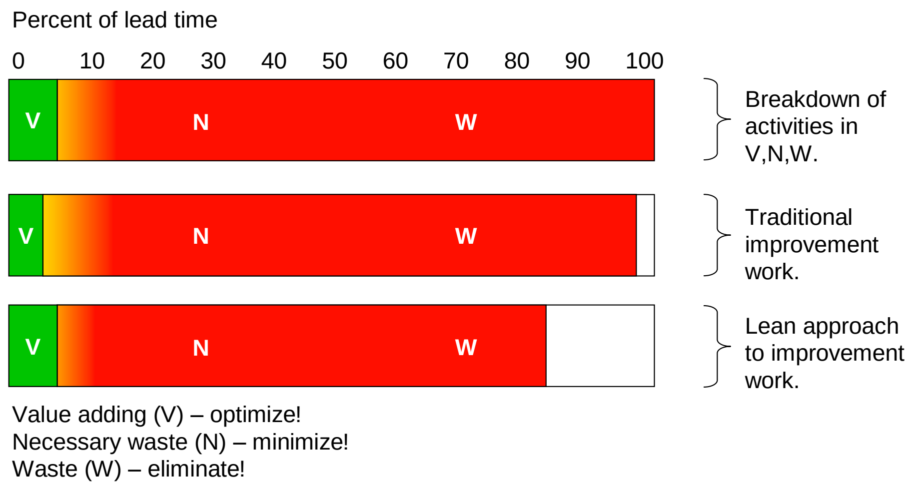


**Figure 13: Value adding processes, necessary waste and pure waste, adapted from Blücher and Öjmertz (2006).**

In VSM the processes; transport, handling and administration are measured in time. This is both supported by the theory from lean production and the empirical study. An example of this is visualized in Figure 14. The value added time is V, the necessary waste is N and the pure waste is W.

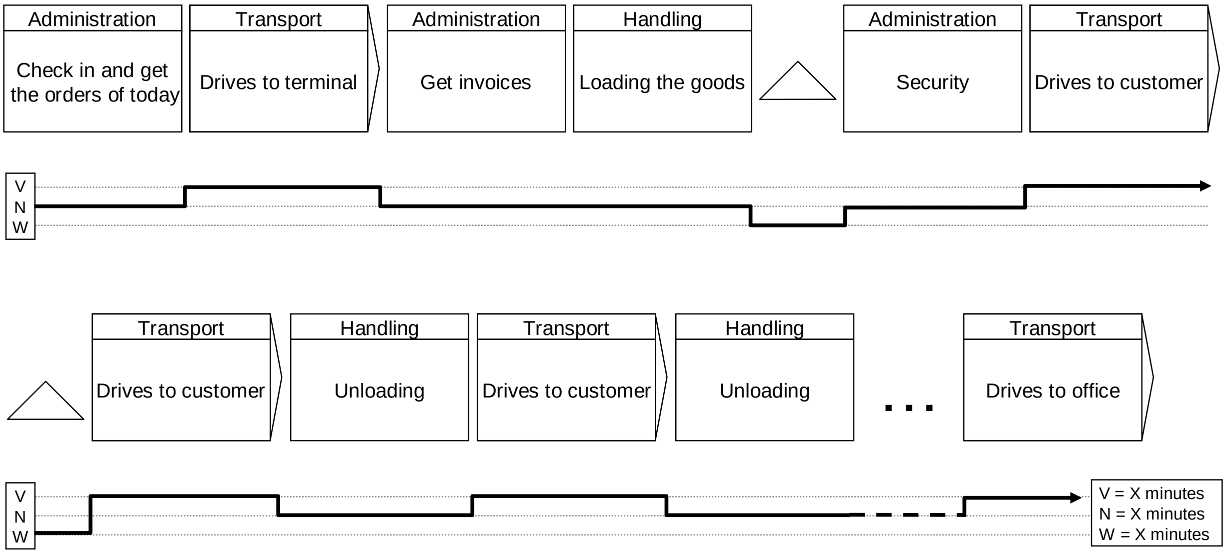


**Figure 14: Example of a VSM in goods flow in a real world study.**

The result from the VSM can also be illustrated in a diagram. The result from the above VSM can be seen in Figure 15.

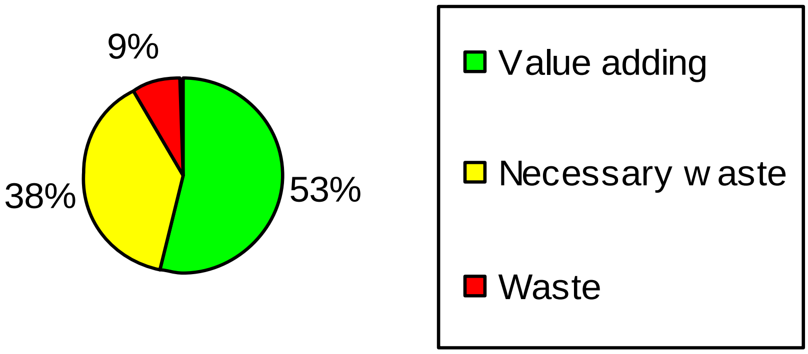


**Figure 15: Example how to illustrate the result from VSM in goods flow.**

## *6.4 Measuring the Identified Waste*

The analysis shows that measure of waste in haulers' operations can be done using a set of KPIs as suggested in the literature. The analysis also shows that several grouped KPIs could be used to measure haulers' overall performance.

The analysis further shows that the KPIs presented in the literature could be expanded to be more comprehensive. In Table 28 are the expanded set of KPIs to measure waste in haulers' operations presented.

The first additional KPI "Percentage Value Adding Time" could be calculated using the definition of what is considered as value adding time from a customer's point of view and total time. In this master's thesis transport activities are considered as value adding and all other processes are considered either necessary waste or pure waste. The transport work is derived from the mapping as described in section 6.3.

Measuring the eight form of waste, unused employee creativity, is far from straight forward. The topic is subjective and difficult to measure. Using the additional KPI “Employee Satisfaction Index” and design a measure based on different parameters such as empowerment, educational level, experience, communication et cetera. The Employee Satisfaction Index will not be further defined in this master’s thesis and further work on this topic is suggested.

**Table 28: Set of KPIs to measure waste in haulers’ operations.**

| Area | KPI | Description |
|---|---|---|
| Cost | Average cost per unit delivered (SEK) | Average cost of delivering a specified unit (e.g. a pallet or tonne of goods). |
| | Total whole vehicle cost (SEK per km) | Total cost of your fleet per mile. Made up of running, standing and driver costs. |
| | Average running cost (SEK per km) | Average cost of running your fleet per mile. These are the costs incurred for running the vehicles (fuel, tyres and maintenance). |
| | Average standing cost (SEK per km) | Average standing cost for your fleet. Standing costs are those incurred whether or not the vehicle is running - depreciation of the vehicle, road fund license (vehicle excise duty), operator license fees and insurance. |
| | Average driver cost (SEK per km) | Average cost of drivers’ wages per kilometre. |
| | Total maintenance cost (SEK per km) | Total cost of maintaining the fleet per kilometre. |
| | Total maintenance cost (SEK) | Total cost of maintaining the fleet. |
| Operational | Average km per litre | Average fuel consumption rate for your fleet. |
| | Total km run | Total number of miles run by your fleet. |
| | Total empty km run | Total number of miles run by your fleet without a payload. |
| | Percentage empty running total | Percentage of distance run by your fleet without a payload. |
| | Percentage Average vehicle fill | This calculates the percentage of actual load carried against the potential capacity of the vehicle fleet. |
| | Percentage Average time utilisation | This calculates the percentage of time that the vehicle fleet was actually in use against the potential time available. |
| | Percentage Value Adding Time | Percentage of the time were actual transport work is performed. |
| Service | Percentage of late deliveries total | Percentage of late deliveries made by your fleet. |
| | Percentage of damages total | Percentage of deliveries made by your fleet where the goods were either missing or damaged. |
| | Percentage of complaints total | Percentage of deliveries made by your fleet that resulted in a complaint of any nature. |

| Area | KPI | Description |
|---|---|---|
| Compliance | Total number of overloads | Total number of overloads in the fleet. |
| | Total number of vehicle traffic infringements | Total number of traffic infringements in the fleet. |
| | Total number of drivers' hours infringement | Total number of drivers' hours infringements in the fleet. |
| | Total number of traffic accidents | Total number of traffic accidents in the fleet. |
| Maintenance | Percentage of failed inspections total | Percentage of failed or overdue safety inspections for your fleet. |
| | Percentage of defects rectified in 24 hours total | Percentage of vehicle defects reported by drivers that are rectified within 24 hours. |
| Environmental | Total fleet $CO_2$ | Total $CO_2$ produced by fleet (tonnes). |
| | Average fleet $CO_2$ | Average $CO_2$ produced by fleet (kg/km). |
| Organizational | Employee Satisfaction Index | The satisfaction of the company's employees. |

The analysis and the conducted test case also show that collecting data is far from straight forward. The procedure data collected differ between companies and the quality of the data can be questioned.

## 6.5 Methodology to Visualize, Identify and Measure Waste

Concluded from chapter 6.1-6.4 a methodology to identify, visualize and measure waste is developed. The methodology is illustrated in Figure 16 and aims to answers the four research questions in this Master's Thesis. The base of the methodology is the interviews and the VSM. Those actions are supported by a knowledge base with waste and KPIs. After carried out interviews and VSM there will be new input to the knowledge base.

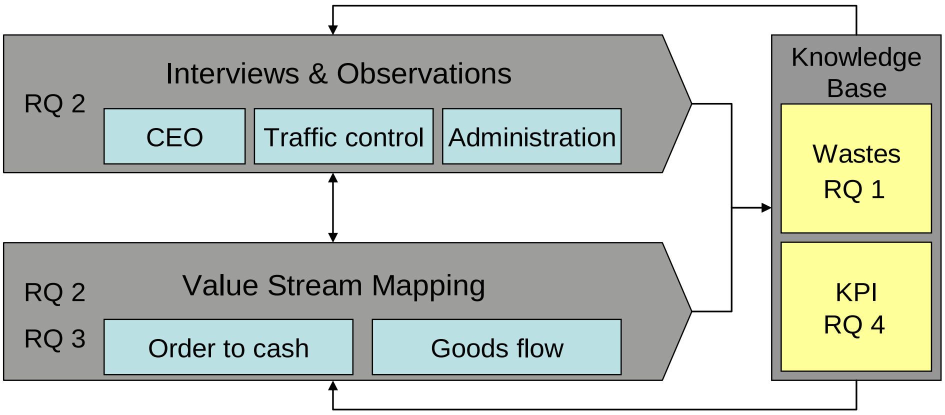


**Figure 16: Methodology to visualize, identify and measure waste.**

## 6.6 *Methodology - Test Case*

To test the findings in the result a test study have been carried out at a medium size hauler based in Sweden. The main service provided by the company is road transport between rail and boat, in a bigger network of intermodal transportation. The results from the case study are presented in the following sections.

### 6.6.1 Identified Waste

The different forms of waste that have been identified in the test case are listed in Table 29 below. The data have been collected with interviews and observations as described in the methodology above. The order to cash process is mapped to entirely understand its impact on the goods flow. Overprocessing was found to be common form of waste. The data entry was made several times by different persons and the orders were faxed between different departments within the same company.

**Table 29: Identification of waste in test case.**

| Form of waste | Description |
|---|---|
| Overproduction | Insufficient information flow between traffic control and driver. |
| | Same data is entered several times. |
| | It-systems are not integrated. |
| Waiting | Waiting at the customer's site. |
| | Waiting for the traffic control. |
| | Securing of the goods not proper done. |
| | Unsynchronized working hours. |
| Unnecessary transport | Short term planning leads to not optimized routes. |
| | Lack of communication leads to not optimized routes. |
| Overprocessing or incorrect processing | Difficult and complex to measure fuel consumption et cetera. |
| | A lot of manual paperwork. |
| Excess inventory | Large gas tank. |
| Unnecessary movement | Design of back plate lift. |
| Defects | Cost of vehicle damage. |
| Unused employee creativity | Educational level. |
| | Attitude towards drivers. |
| | Eco-driving. |

### 6.6.2 Visualization of Identified Waste

The transport of goods has been mapped as described in the methodology. The mapping was made by going with a truck at the case company. See Appendix F for the data collected during the trip. The visualization of the waste is showed in Figure 17. The result of the mapping is shown in a diagram in Figure 18.

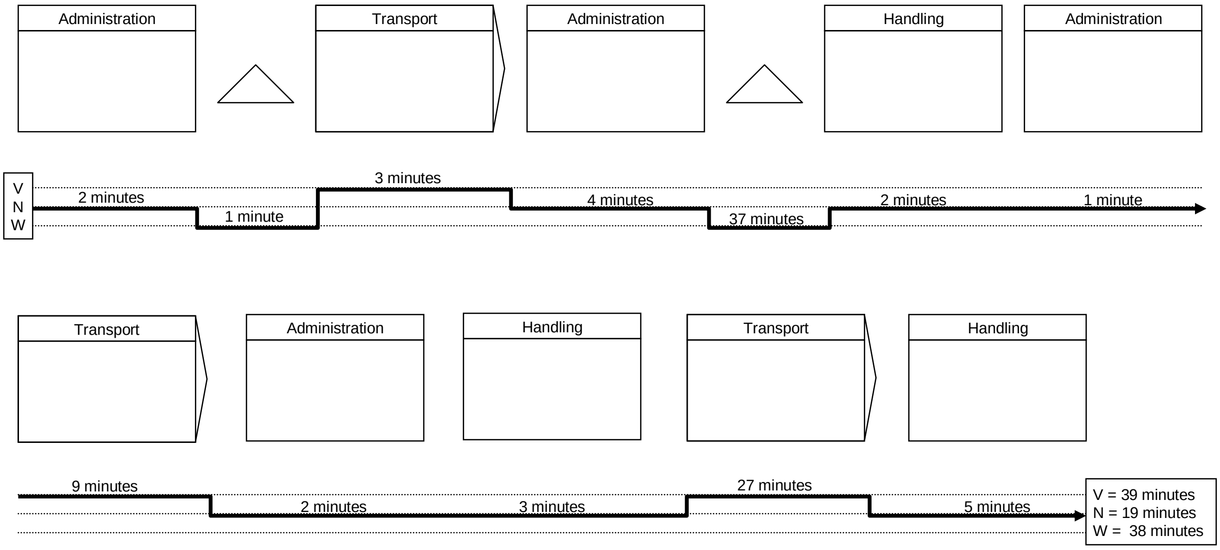


**Figure 17: Visualisation of waste in test case.**

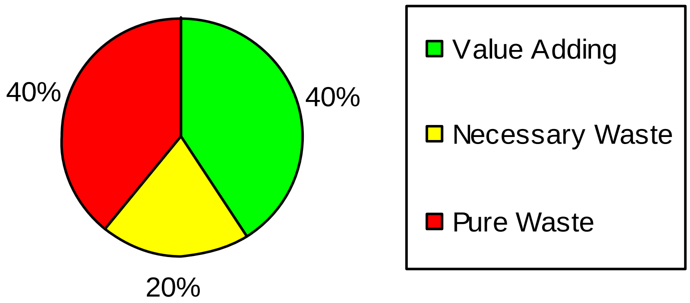


**Figure 18: Results from mapping in test case.**

### 6.6.3 Measuring the Identified Waste

The identified waste have been collected using the set of measures described in Figure 9. The results are presented in Table 30 below.

**Table 30: Data collected in test case with KPI data collection protocol.**

| Measure | Data |
|---|---|
| Kilometre travelled | [Data missing] |
| Units delivered | [Data missing] |
| Number of km travelled without load / year | [Data missing] |
| Time vehicle available | 24 hours / day |
| Time vehicle used | 9-10 hours / day |
| Own driver costs | 235,00 SEK / hour |
| Agency driver costs | 280,00 SEK / hour |
| Fuel litre consumed | 4,12 litre / 10 kilometre |
| Fuel costs / year | [Data missing] |

| Measure | Data |
|---|---|
| Tyre costs / year | [Data missing]. |
| Maintenance cost unplanned /planned / year | [Data missing] |
| Insurance cost / year | [Data missing] |
| Road fund licence cost / year | [Data missing] |
| Vehicle rental cost / year | [Data missing] |
| Vehicle leasing cost / year | Don't use leased vehicles. |
| Vehicle deprecation cost / year | [Data missing] |
| Total CO2 emission | [Data missing] |
| Vehicle damage cost | 500 000 SEK |

### 6.6.4 Key Learnings from the Test Case

To identify different kinds of waste by conducting observations and interviews works very well. To group the waste according to the waste model was beneficial to get a good overview.

The mapping worked well but in this case there were some special circumstances which have to be taken into consideration.

Since the set of collected data in Table 30 is incomplete the KPIs could not be derived. Much of the data are available at the economic department in Stockholm but as the time was not enough to collect this data, a conclusion drawn from the test case is to a couple of weeks in advance send the KPI data collection protocol to the company. Another conclusion is that it is very time consuming and difficult to collect data when the company don't work with data collection and follow-up themselves.

## *6.7 Methodology - Validation Case*

To validate the methodology described in section 6.5 a case study have been carried out at a medium size hauler based in Sweden. The main service provided by the company is distribution for one of the major logistics provider in Europe. The company also offers transport of goods in smaller scale for some of its customers. The results from the case study are presented in the following sections.

### 6.7.1 Identified Waste

Some examples of the different forms of waste that have been identified in the validation case are listed in Table 31. The data have been collected with interviews and observations as described in the methodology.

**Table 31: Identification of waste in validation case.**

| Form of waste | Description |
|---|---|
| Overproduction | Insufficient information flow between traffic control and driver. |
| | Driver takes a long time to find the customer. |
| | Trying to deliver goods when customer is not available. |
| Waiting | Waiting for the customer. |

| Form of waste | Description |
|---|---|
| Unnecessary transport | Lack of communication leads to not optimized routes. |
| Overprocessing or incorrect processing | Much manual paperwork. |
| Excess inventory | A lot of papers to archive. |
| | Trucks standing in the yard. |
| Unnecessary movement | Design of back plate lift. |
| Defects | Cost of vehicle damage. |
| | Damaged goods. |
| Unused employee creativity | Attitude towards drivers. |
| | Complaints from customers. |
| | Eco-driving education not done. |

### 6.7.2 Visualization of Identified Waste

The transport of goods has been mapped as described in the methodology. See Appendix G for the data collected during the trip. The visualization of the waste is showed in Figure 19. The result from the mapping is shown in a diagram in Figure 20.

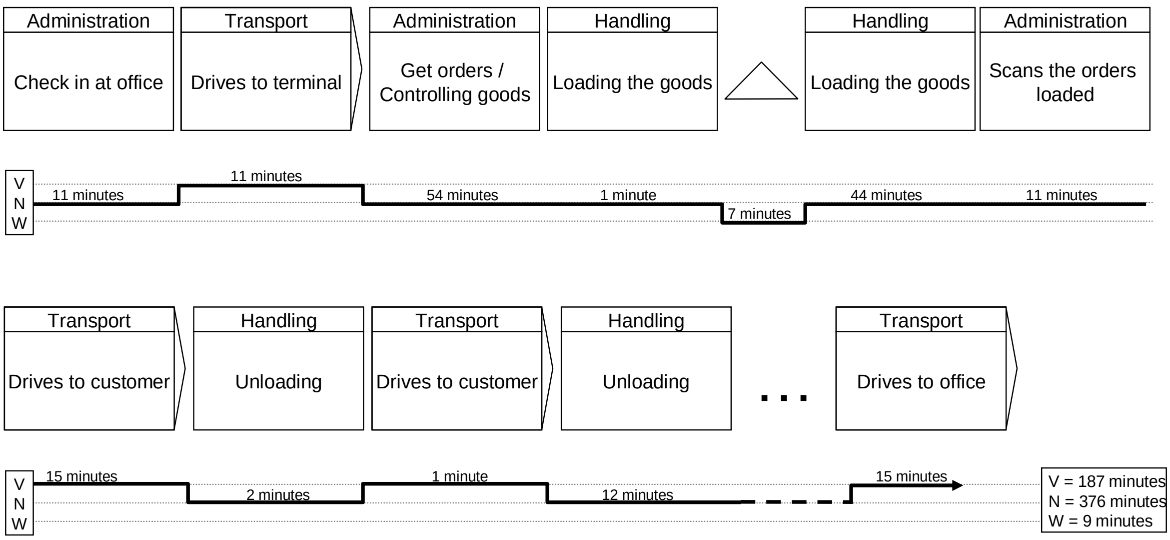


**Figure 19: Visualisation of waste in validation case.**

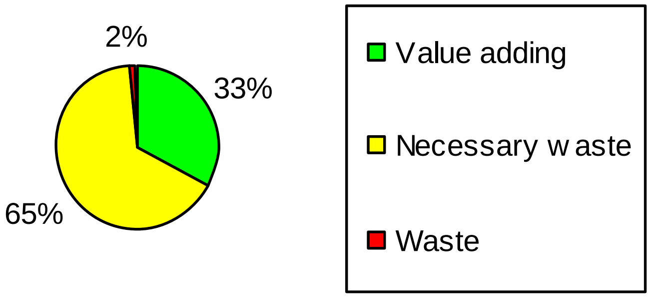


**Figure 20: Results from mapping in validation case.**

The result from the mapping shows that 65 percent of the driver's working day was administrative or handling of the goods. With efficiency improvements this time can be assumed to decrease to 50 percent. The yearly cost for those 15 percentage points will be illustrated in a simple example. Assuming working days of 8 hours, 220 working days per year, a cost of 220 SEK per hour for the driver and a cost of 70 SEK per hour for the truck. The cost of the 15 percentage points necessary waste will end up in 77 000 SEK per truck and year.

### 6.7.3 Measuring the Identified Waste

The identified waste have been collected using the set of measures described in Figure 9. The results are presented in Table 32 below. These measures have then been put together to different KPIs, which are presented in Table 33.

**Table 32: Data collected in validation case with KPI Data Collection Protocol.**

| Data | Measure |
|---|---|
| Kilometre travelled / year | 1 081 000 |
| Units delivered / year | 1 300 00 |
| Number of km travelled without load / year | 30 % |
| Time vehicle available hours / day | 24 |
| Time vehicle used hours / day | 8.7 |
| Own driver costs SEK / year | 25 922 000 |
| Agency driver costs SEK/ year | 5 616 000 |
| Fuel litre consumed litre / year | 596 000 |
| Fuel costs SEK / year | 6 000 000 |
| Tyre costs SEK / year | 548 000 |
| Maintenance cost unplanned /planned SEK / year | 3 506 000 |
| Insurance cost SEK / year | 120 700 |
| Road fund licence cost SEK / year | 1 122 000 |
| Vehicle rental cost SEK / year | 80 000 |
| Vehicle leasing cost SEK / year | 322 800 |
| Vehicle deprecation cost SEK / year | 6 236 000 |
| Total CO2 emission | [Data missing] |

**Table 33: Measure of waste in validation case.**

| Area | KPI | Measure and Description |
|---|---|---|
| Cost | Average cost per unit delivered (SEK) | 38,32 |
| | Total whole vehicle cost (SEK per km) | 45,77 |
| | Average running cost (SEK per km) | 38,48 |
| | Average standing cost (SEK per km) | 7,22 |
| | Average driver cost (SEK per km) | 29,17 |
| | Total maintenance cost (SEK per km) | 3,24 |
| | Total maintenance cost (SEK) | 3 506 000 |
| Operational | Average litre per km | 0,55 |
| | Total km run | 1 081 000 |
| | Total empty km run | 324 300 |
| | Percentage empty running total | 30 |
| | Percentage Average vehicle fill | [Data missing] |
| | Percentage Average time utilization | 36,25 |
| Service | Percentage of late deliveries total | [Data missing] |
| | Percentage of damages total | [Data missing] |
| | Percentage of complaints total | 0,01 % |
| Compliance | Total number of overloads | 0 |
| | Total number of vehicle traffic infringements | [Data missing] |
| | Total number of drivers' hours infringement | 0 |
| | Total number of traffic accidents | [Data missing] |
| Maintenance | Percentage of failed inspections total | [Data missing] |
| | Percentage of defects rectified in 24 hours total | [Data missing] |
| Environmental | Total fleet $CO_2$ | [Data missing] |
| | Average fleet $CO_2$ | [Data missing] |

### 6.7.4 Key Learnings from the Validation Case

In the validation case the framework with observations and interviews worked very well. The classification of waste in categories according to the waste model was beneficial to get an overview.

The key learning from the test case to send the KPI data collection protocol a couple of weeks in advance worked well in the validation case and almost all data were collected. In this case the collected data from the company were covering almost all selected KPIs, which show that the KPI set works very well.

The transports in the validation case were a bit different compared to the transports in the test case, but the methodology worked in both cases. This indicates that the methodology is flexible to use in different transport set ups.

# 7 Discussion, Recommendations and Continued Research

*This chapter presents a short discussion, recommendations and is concluded with suggestions for continued research.*

## 7.1 Discussion

In the validation case 65 percent of the driver's working day was administrative or handling of the goods. With efficiency improvements this time can be assumed to decrease to 50 percent. The yearly cost for those 15 percentage points will be illustrated in an example: assuming a 8 hours working day, 220 working days per year, a cost of 220 SEK per hour for the driver and a cost of 70 SEK per hour for the truck; the cost will end up in 77 000 SEK per truck and year. This cost could of course be multiplied by the number of trucks used in the company. This is only one example; the situation could be either better or worse. The important part is that this illustrates the huge cost of waste in haulers' operations.

The methodology presented in this master's thesis has been tested and validated for distribution and short haul operations. It is intended that the methodology works for long haul operations as well, and one could argue that the operations resemble short haul operations. However, the methodology is not tested nor validated in this setting.

The definition of lean is inconsistent in the literature and different authors use different definitions. In this master's thesis, the term lean was chosen as an umbrella term for lean production (referring to methods such as kanban and takt time) and lean thinking (referring to the philosophical aspect of lean). The methodology developed in this master's thesis is closer related to the methods of lean production but defining value adding from a customers' perspective is more related to lean thinking. We have therefore chosen not to distinguish between the two terms since both perspectives are used. This could of course be criticized to be vague.

Value adding activities are defined as transport, i.e. when the truck is not standing still, in this master's thesis. The delimitations of the master's thesis include both fill rate and route optimization. One could then argue that as long as the truck is not standing still the truck is assumed to be fully loaded and travelling the optimal route. This is of course far from reality but when using these assumptions it was possible to set focus on the operations rather than the planning of the routes.

The usage of a set of KPIs to measure waste answers RQ4: *"How could waste in haulers' operations be measured?"* However the master's thesis does not answer what the KPIs actually means. This is unfortunately a rather complicated question. The example of the waste unnecessary high fuel consumption used in section 0 exemplifies this. The fuel consumption depends on a number of parameters such as the weight of the load, travel speed, number of stops et cetera. A fuel consumption of 4.5 litres per kilometre could be very good for some transport assignments while the same fuel consumption for another assignment could be considered high. This illustrates the difficulties to interpret the value of the KPI.

The measure of waste using a set of KPIs could be viewed as a snapshot of the current state of a hauler's operations. By extending the measurement of waste to a continuous monitoring of the performance by measuring performance in regular time intervals, the hauler could assess performance trends over time and thereby benchmark the performance with historical data.

This benchmarking approach could also be extended from a comparison of internal data to benchmarking data with external organisations. By benchmarking the performance with other companies it would be possible to get an objective view of what the hauler does well and what areas could be improved. This type of comparison between haulers already exists in the United Kingdom through an initiative by the U.K. Department for Transport. This type of programme is unfortunately not present in many other countries.

The identification, visualization and measurement of waste in haulers' operations are only the first steps towards a complete lean transformation. A lot of work for both practitioners and academics are still to be done.

## 7.2 Recommendations

Haulers could improve their competitive edge by taking a lean perspective on their operations, define what is value adding from the customer's perspective and eliminate or minimize waste in their operations. This could help them to handle the increased complexity and pressured profit margins to boost profitability and increase customer satisfaction.

A methodology to identify, visualize and measure waste has been presented in this master's thesis. This is the first step to eliminate or to minimize waste in haulers' operations. The methodology has been tested and validated for the Swedish market. We recommend any interested hauler to start working with the methodology.

We also recommend that a national programme for benchmarking performance in haulers' operations should be initiated. This could be beneficial for both haulers, researchers, truck manufactures and other stakeholders related to the road transport business. Such a programme should preferably be initiated and hosted by a neutral organisation to ensure impartiality. Such an organisation could be a haulage associations or governmental department.

## 7.3 Continued Research

The developed methodology is a first step towards a complete lean transformation for a hauler. The next step of the lean journey is to implement improvements to eliminate or to minimize waste in the operations. This calls for further research on how lean principles can be adapted to be applied in haulers' operations. Implementation of improvement teams, standardization of work tasks, 5S and continuous improvement work are just a few examples of interesting fields for further research.

A more extensive study could cover more aspects that are not considered in this thesis. Fill-rate and route optimization are two aspects that could be included in such a study. An interesting field of research is how a lean transformation would interact and affect such aspects.

It is difficult to measure waste and the collection of data is time consuming. To be able to perform a correct assessment of a hauler's operations, benchmarking data has to be available. This calls for further research on how a benchmarking tool, to compare KPIs, can be designed.

All research has limitations. The presented methodology is only tested and validated for distribution and short haul in Sweden. It is the authors' intention that the methodology is applicable for long haul and other regional areas. This calls for further research.

# 8 Conclusions

Small changes in the operational costs can lead to major changes in profit. This master's thesis shows that haulers could improve their competitive edge by taking a lean perspective on their operations by defining what is value adding from the customer's perspective. By using the methodology presented in this thesis waste in haulers' operations could be identified, visualized and measured. The methodology is the first step to improve the operations by eliminating or minimizing waste in the operations. This could help haulers to handle increasing operational costs and low profit margins to boost profitability and at the same time increase customer satisfaction.

Previous research has been conducted with focus on the process flow and information flow in the supply chain operations. Inspired by successful applications of lean principles outside production environment this master's thesis has systematically explored the novel area of application of lean in haulers' operations.

Haulers are depending on the market situation and have to follow ongoing trends in the business. Economical growth, industry development et cetera are factors that affect the fluctuating demand for transports. The transportation business is also challenged by increasing competition from new players on the European market. Other factors such as supporting IT-system and security aspects are becoming more and more important and the work to decrease carbon dioxide ($CO_2$) emissions by efficient logistic planning and eco-driving are essential. Due to the large amount of goods in the supply chain and the trends towards small lot sizes and frequent deliveries, it is necessary to move the goods efficiently.

Based on the literature review a framework for data collection was developed. The framework was used during the extensive empirical study to find ways to identify, visualize and measure waste in haulers' operations. The results from the empirical study show that many different types of waste can be found in haulers' operations. By combining the results from the empirical study and the theoretical framework a methodology to identify, visualize and measure waste in haulers' operations was developed.

The methodology is a structured approach to apply lean in road transport business. It consists of an interview and an observation part as well as a Value Stream Mapping (VSM) tool adapted for haulers' operations. The VSM is conducted in the order-to-cash process and the goods flow to identify and visualize waste. To be able to measure the waste, a definition of what is value adding to the customer was made and a set of Key Performance Indicators (KPIs) directly linked to the waste in the operations was identified. A component of the methodology is a knowledge base consisting of identified waste and collected KPIs to support further use of the methodology.

The methodology has been tested and validated in different case studies. The validation case confirms that the methodology can identify, visualize and measure the waste in haulers' operations and indicates that tools from lean production can successfully be applied in the road transportation business.

Finally this master's thesis has identified interesting areas of future research within the field of applying lean in haulers' operations.

# References

Arnäs, P-O., 2007. Heterogeneous Goods in Transportation Systems – A study on the uses of an object oriented approach. Ph. D. Göteborg: Chalmers University of Technology.

Björklund, M. & Paulsson. U., 2003. *Seminarieboken*. Lund: Studentlitteratur.

Blücher, D., Öjmertz, D., 2008. *Utmana dina processer!* Mölndal: Swerea|IVF.

Brehmer, P-O., 1999. *Towards a Model of Lean Freight Transport Operations*. Ph. D. Linköping: Linköping University.

Bryman, A. & Bell E., 2007. *Business research methods*. 2nd ed. New York: Oxford University Press.

Christopher, M.. & Lee, H., 2004. Mitigating supply chain risk through improved confidence. *International Journal of Physical Distribution & Logistic Management*, 34(5), pp. 388-396.

Environmental Protection Agency, 2003. *Lean Manufacturing and the Environment*. Washington DC: EPA publication.

Foote, N.W. Galbraith, J. Hope, Q. & Miller, D., 2001. Making solutions the answer. *McKinsey Quarterly*, (3), pp.84–93.

Hibberd, J. & Evatt, A., 2004. Mapping Information Flows: A Practical Guide. *The Information Management Journal***,** 38(1), pp. 58-64.

Hines, P. Holweg, M. & Rich, N., 2004. Learning to evolve: A review of contemporary lean thinking. *International Journal of Operations & Production Management*, 24(10), pp. 994-1011.

Hines, P. & Rich, N., 1997. The seven value stream mapping tools. *International Journal of Operations & Production Management*, 17(1), pp. 46-64.

Huan, H.H. Sheoran, S.K. & Wang, G., 2004. A review and analysis of supply chain operations reference (SCOR) model. *Supply Chain Management: An International Journal*, 9(1), pp. 23-29.

International Road Transport Union, 2009. *Impact of the current economic crisis on the road transport industry*. [Online] Available at: http://www.iru.org/index/en_economic-crisis2009 [Accessed: 13 March 2009].

Jonsson, P. & Mattsson, S-A., 2004. *Logistik – Läran om effektiva materialflöden*. Lund: Studentlitteratur.

Kanflo, T., 1999. *Information in Transportation Chains.* Lic. Eng. Göteborg: Chalmers University of Technology.

Keyte, B. & Locher, D., 2004. The Complete Lean Enterprise: Value Stream Mapping for Administrative and Office Processes. New York: Productivity Press.

Klotz, L. Horman, M. Bi, H.H. & Bechtel, J., 2008. The impact of process mapping on transparency. *International Journal of Productivity and Performance Management*, 57(8), pp. 623-636.

Kärkkäinen, M., 2003. Increasing efficiency in the supply chain for short shelf life goods using RFID tagging. *International Journal of Retail & Distribution Management*, 31(10), pp.529-536.

Lasa, I. S. Laburu, C. O. & Castro V. R., 2008. An evaluation of the value stream mapping tool. *Business Process Management Journal*, 14(1), pp. 39-52.

Lewis, M., 2000. Lean production and sustainable competitive advantage. *International Journal of Operations & Production Management*, 20(8), pp. 959-978.

Liker, J., 2004. The Toyota Way: 14 Management Principles from the world greatest manufacturer. New York: CWL Publishing Enterprises.

McKinnon, A. C. & Ge, Y., 2006. The Potential for reducing empty running by trucks: a retrospective analysis. *International Journal of Physical Distribution & Logistics Management*, 36 (5), pp. 391-410.

Patel, R. & Davidson, B., 2003. *Forskningsmetodikens grunder*. Lund: Studentlitteratur.

Piercy, N. & Rich, N., 2009. Lean transformation in the pure service environment: the case of the call service centre. *International Journal of Operations & Production Management*, 29(1), pp.54-76.

Rodrigues, V.S. Stantchev, D. Naim, M. Potter, A. & Whiteing, A., 2008. Establishing a transport operation focused uncertainty model for the supply chain. *International Journal of Physical Distribution & Logistics Management,* 38(5), pp. 388-411.

Rother, M. & Shook, J., 2003. *Learning to see: value-stream mapping to create value and to eliminate muda.* Version 1.3. Cambridge: The Lean Enterprise Institute.

Ryen, A., 2004. *Kvalitativ intervju*. Malmö; Liber.

Simons, D. & Zokaei, K. 2005. Application of lean paradigm in read meet industry. *British Food Journal,* 107(4), pp.192-211.

Sjöstedt, L., 1994. *Sustainable Mobility.* Zurich: SATW (Schweizeriche Akademie der Technichen Wissenschaften).

Souza, L. B., 2009. Trends and approaches in Health Services. *Leadership in Health Services*, 22 (2), pp. 121-139.

Stefansson, G., 2004. Collaborative Logistics Management – The role of third-party service providers and the enabling information systems architecture. Ph. D. Göteborg: Chalmers University of Technology.

Sternberg, H., 2008. Transport visibility and information sharing: a case study of actor's requirements. *World Review of Intermodal Transportation Research*, 2(1), pp.54-71.

Swedish Association of Road Haulage Companies. 2008. *Fakta om åkerinäringen.* [Online] Swedish Association of Road Haulage Companies. Available at: http://www.akeri.se/sveriges-akeriforetag/media/informations-material [Accessed 3 April 2009].

U.K. Department for Transport , 2008. *Performance Management for Efficient Road Freight Operations Guide*. [Online] Available at: http://www.freightbestpractice.org.uk [Accessed 10 March 2009].

U.K. Department for Transport , 2009. *Publications - Freight Best Practise*. [Online] Available at: http://roadtransport.firstlightera.com/EN/Microsites/1/Freight+Best+Practice/Publications [Accessed 12 March 2009].

U.S. Department of Transportation, Federal Motor Carrier Safety Administration, 2007. *The Motor Carrier Efficiency Study 2007 Annual Report to Congress.* [Online] Available at: http://www.fmcsa.dot.gov/facts-research/research-technology/report/Emerging_Detection_Measures_508.pdf [Accessed 2 April 2009].

Volvo Group, 2007. *Annual report 2007*. [Online] Available at: http://www3.volvo.com/investors/finrep/ar07/annual_report_2007_eng.pdf [Accessed 22 January 2009].

Womack, J.P. Jones, D.T. & Roos, D., 1990. *The Machine That Changed the World*. New York: Simon & Schuster, Inc.

Yin, R. K., 2006. Case study research: Design and Methods. Malmö: Liber.

# Appendix A – Case Study Protocol

Interview - Company
Respondent:
Position:
Interviewer:
Company:
Date:

**Objectives with the interview**
When doing the interview these issues are the main issues to search:

**Questionnaire (in Swedish)**

**Introduction**
*Introduktion av ditt arbetsområde*
*Vilka tidigare erfarenheter har du?*

**RQ 1 - What type of waste can be identified in a Haulers operation?**
Har du genomfört några projekt inom transportbranschen?
Har du någon erfarenhet från åkeribranschen?
Vilka olika former av slöseri kan du tänka dig att det finns i ett åkeris verksamhet?

**RQ 2 - How can the waste be identified?**
Har du någon erfarenhet av förbättringsarbete?
Vilka verktyg och metoder kan vara användbara för att identifiera slöserier i en verksamhet?
Hur kan den här typen av metoder och verktyg standardiseras för att kunna appliceras generellt i olika versamheter?
Vilka verktyg och metoder kan vara lämpliga specifikt för ett åkeris verksamhet?

**RQ 3 - How can the identified waste be visualized?**
Har du någon erfarenhet av att visualisera slöserier i en verksamhet?
Har du något bra exempel på detta?
Har du något förslag på metoder för att detaljera processer, till exempel för att analysera enskilda aktiviteter och arbetsmoment?
Vilka för- och nackdelar skulle en tillämpning av Value Stream Mapping ha för identifieringen av slöseri i ett åkeris verksamhet?
Vilka anpassningar av Value Stream Mapping metodiken skulle du kunna tänka dig?
Beskriv hur Value Stream Mapping metoden används i ett projekt?

**RQ 4 - How can the identified waste be measured?**
Hur har du jobbat med mätbarhet av resultaten i tidigare projekt?
Hur har mätetalen valts? Vad blev resultatet?
Hur visualiserades resultatet?
Vilka mätetal kan vara användbara för att mäta slöseri?
Vilka olika KPI:er (Key Performance Indikators) kan vara användbara vid analys av ett åkeri?

# Appendix B – Overview Interviews

| | | | Hauler Operational Manager 1 | Hauler Operational Manager 2 | Hauler Operational Manager 3 | Lean Expert 1 | Lean Expert 2 | Lean Expert 3 | Lean Expert 4 | Lean Expert 5 | Business Analyst 1 | Business Analyst 2 | Business Analyst 3 | Volvo General Manager 1 | Volvo General Manager 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RQ1 | 1.1 | Har du genomfört några projekt inom transportbranschen? | | | | | X | X | | X | X | X | X | X | X |
| | 1.2 | Har du någon erfarenhet från åkeribranschen? | X | X | X | | | | | | X | X | X | X | |
| | 1.3 | Vilka olika former av slöseri kan du tänka dig att det finns i ett åkeris verksamhet? | X | X | X | X | X | X | | X | X | X | X | X | X |
| RQ2 | 2.1 | Har du någon erfarenhet av förbättringsarbete? | X | X | X | X | X | X | X | X | X | X | X | X | X |
| | 2.2 | Vilka verktyg och metoder kan vara användbara för att identifiera slöserier i en verksamhet? | X | X | X | X | X | X | X | X | | | X | X | X |
| | 2.3 | Hur kan den här typen av metoder och verktyg standardiseras för att kunna appliceras generellt i olika versamheter? | | | | X | X | | X | X | | | | X | |
| | 2.4 | Vilka verktyg och metoder kan vara lämpliga specifikt för ett åkeris verksamhet? | X | X | X | | | | X | X | | | X | X | |
| RQ3 | 3.1 | Har du någon erfarenhet av att visualisera slöserier i en verksamhet? | X | X | X | X | X | | X | X | | X | X | X | X |
| | 3.2 | Har du något bra exempel på detta? | X | X | X | X | | | | | | X | X | | |
| | 3.3 | Har du något förslag på metoder för att detaljera processer, till exempel för att analysera enskilda aktiviteter och arbetsmoment? | X | X | | X | X | | X | X | | | X | X | X |
| | 3.4 | Vilka för- och nackdelar skulle en tillämpning av Value Stream Mapping ha för identifieringen av slöseri i ett åkeris verksamhet? | | | | X | X | X | X | X | | | X | | |
| | 3.5 | Vilka anpassningar av Value Stream Mapping metodiken skulle du kunna tänka dig? | | | | X | X | | X | X | | | X | | |
| | 3.6 | Beskriv hur Value Stream Mapping metoden används i ett projekt? | | | | X | | | | X | | | | | |
| RQ4 | 4.1 | Hur har du jobbat med mätbarhet av resultaten i tidigare projekt? | X | X | X | X | X | X | X | X | | X | X | X | X |
| | 4.2 | Hur har mätetalen valts? Vad blev resultatet? | X | X | X | X | | | | X | | X | X | X | |
| | 4.3 | Hur visualiserades resultatet? | X | | | X | | | | X | X | X | X | | |
| | 4.4 | Vilka mätetal kan vara användbara för att mäta slöseri? | | | | X | | | | X | X | X | X | X | |

# Appendix C - Interviews

## *Appendix C.1 – Interviews Hauler Operational Manager*

### Appendix C.1.1 Interview Hauler Operational Manager 1

Respondent: [Not disclosed]
Date: 2009-03-05
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the CEO's perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to achieve a top management perspective of their business and its operations, e.g. waste in their own organization and an overview of the information flow.

Another aim is to achieve insight in the top management daily work and his/her role in the organization.

**Questionnaire: see Appendix A**

## Appendix C.1.2 – Interview Hauler Operational Manager 2

Respondent: [Not disclosed]
Date: 2009-03-09
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the CEO’s perspective of waste in haulers’ operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master’s thesis.

A further objective with the interview is to achieve a top management perspective of their business and its operations, e.g. waste in their own organization and an overview of the information flow.

Another aim is to achieve insight in the top management daily work and his/her role in the organization.

**Questionnaire: see Appendix A**

## Appendix C.1.3 – Interview Hauler Operational Manager 3

Respondent: [Not disclosed]
Date: 2009-02-13
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the CEO’s perspective of waste in haulers’ operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master’s thesis.

A further objective with the interview is to achieve a top management perspective of their business and its operations, e.g. waste in their own organization and an overview of the information flow.

Another aim is to achieve insight in the top management daily work and his/her role in the organization.

**Questionnaire: see Appendix A**

## *Appendix C.2 – Interviews Lean Expert*

### Appendix C.2.1 – Interview Lean Expert 1

Respondent: [Not disclosed]
Date: 2009-02-20
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the lean experts perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to achieve a lean expert view of the transportation business.

Another aim is to acquire knowledge of the lean expert previous work experience with identifying, measuring and visualizing waste.

A further objective is to achieve the lean expert point of view if the lean philosophy is applicable in the transportation business.

**Questionnaire: see Appendix A**

## Appendix C.2.2 – Interview Lean Expert 2

Respondent: [Not disclosed]
Date: 2009-03-16
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the lean experts perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to achieve a lean expert view of the transportation business.

Another aim is to acquire knowledge of the lean expert previous work experience with identifying, measuring and visualizing waste.

A further objective is to achieve the lean expert point of view if the lean philosophy is applicable in the transportation business.

**Questionnaire: see Appendix A**

## Appendix C.2.3 – Interview Lean Expert 3

Respondent: [Not disclosed]
Date: 2009-03-17
Company: [Not disclosed]
Position: [Not disclosed]
Interviewer: Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the lean experts perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to achieve a lean expert view of the transportation business.

Another aim is to acquire knowledge of the lean expert previous work experience with identifying, measuring and visualizing waste.

A further objective is to achieve the lean expert point of view if the lean philosophy is applicable in the transportation business.

**Questionnaire: see Appendix A**

## Appendix C.2.4 – Interview Lean Expert 4

Respondent: [Not disclosed]
Date: 2009-03-13
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the lean experts perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to achieve a lean expert view of the transportation business.

Another aim is to acquire knowledge of the lean expert previous work experience with identifying, measuring and visualizing waste.

A further objective is to achieve the lean expert point of view if the lean philosophy is applicable in the transportation business.

**Questionnaire: see Appendix A**

## Appendix C.2.5 – Interview Lean Expert 5

Respondent: [Not disclosed]
Date: 2009-03-18
Company: [Not disclosed]
Position: [Not disclosed]
Interviewer: Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the lean experts perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to achieve a lean expert view of the transportation business.

Another aim is to acquire knowledge of the lean expert previous work experience with identifying, measuring and visualizing waste.

A further objective is to achieve the lean expert point of view if the lean philosophy is applicable in the transportation business.

**Questionnaire: see Appendix A**

# Appendix C.3 – Interviews Business Analyst

## Appendix C.3.1 – Interview Business Analyst 1

Respondent: [Not disclosed]
Date: 2009-04-17
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the business analyst perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to acquire knowledge of a business analyst experience from measuring performance.

An other aim with the interview is to achieve a business analyst view of the transportation business.

**Questionnaire: see Appendix A**

## Appendix C.3.2 – Interview Business Analyst 2

Respondent: [Not disclosed]
Date: 2009-02-02
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the business analyst perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to acquire knowledge of a business analyst experience from measuring performance.

An other aim with the interview is to achieve a business analyst view of the transportation business.

**Questionnaire: see Appendix A**

## Appendix C.3.3 – Interview Business Analyst 3

Respondent: [Not disclosed]
Date: 2009-02-26
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get the business analyst perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to acquire knowledge of a business analyst experience from measuring performance.

An other aim with the interview is to achieve a business analyst view of the transportation business.

**Questionnaire: see Appendix A**

## *Appendix C.4 – Interviews Volvo General Manager*

### Appendix C.4.1 – Interview Volvo General Manager 1

Respondent: [Not disclosed]
Date: 2009-03-11
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get a truck manufactures perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to acquire knowledge of a Volvo managers experience from the transportation business.

An other aim with the interview is to achieve an additional perspective on the haulers business.

**Questionnaire: see Appendix A**

## Appendix C.4.2 – Interview Volvo General Manager 2

Respondent: [Not disclosed]
Date: 2009-03-12
Company: [Not disclosed]
Position: [Not disclosed]
Interviewers: Rikard Larsson & Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get a truck manufactures perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to acquire knowledge of a Volvo managers experience from the transportation business.

An other aim with the interview is to achieve an additional perspective on the haulers business.

**Questionnaire: see Appendix A**

## Appendix C.4.3 – Interview Volvo General Manager 3

Respondent: [Not disclosed]
Date: 2009-03-19
Company: [Not disclosed]
Position: [Not disclosed]
Interviewer: Emma Westerberg

**Objectives with the interview:**

The overall objective of the interview is to get a truck manufactures perspective of waste in haulers' operations. The input data is a part of the whole set of data, which ultimately answers the four RQs in this master's thesis.

A further objective with the interview is to acquire knowledge of a Volvo managers experience from the transportation business.

An other aim with the interview is to achieve an additional perspective on the haulers business.

**Questionnaire: see Appendix A**

# Appendix D - Value Stream Mapping Observation Protocol

| | | |
|---|---|---|
| Company: | Date: | Trip meter start: |
| Driver: | Observer: | Trip meter stop: |
| Value flow: | Page: | Total kilometres: |

| Start | Time | Process (T, H, A, Waiting) | Description | Waste in process | Load | Address |
|---|---|---|---|---|---|---|
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# Appendix E - Data Collecting Protocol KPI

| |
|---|
| Company: |
| Respondent: |
| Date: |
| Interviewer: |

| Data | Beskrivning | Värde | Enhet (Exempel km / år) |
|---|---|---|---|
| Körda kilometer / år | Antal körda kilometrar för hela fordonsflottan per år. | | |
| Antal fordon | Antal tillgängliga fordon (Dela gärna upp antal per typ av fordon) | | |
| Antal enheter levererade / år | Hur många enheter som levereras per år. (Specificera gärna antal europallar, container, trailer etc) | | |
| Antal körda km utan last / år | Antal kilometer som hela fordonsflottan rullar per år utan gods (tom körning). | | |
| Tillgänglig fordonstid | Hur många timmar om dygnet är fordonsflottan tillgänglig (Ta bort planerat underhåll mm.) | | |
| Använd fordonstid | Hur många timmar om dygnet används fordonsflottan i genomsnitt per dygn | | |
| Kostnad för egna chaufförer / år | Total kostnad för egna chaufförer per år | | |
| Kostnad för inhyrda chaufförer / år | Total kostnad för inhyrda chaufförer per år | | |
| Åtgång volym bränsle / år | Total förbrukad volym bränsle per år | | |
| Bränslekostnad / år | Totalkostnad för bränsle per år | | |
| Däckkostnad / år | Total kostnad för däck per år | | |
| Underhållskostnader planerade & oplanerade / år | Total kostnad för planerat och oplanerat underhåll per år | | |
| Försäkringskostnader | Total kostnad för försäkringar per år | | |
| Fordonsskattekostnader | Total kostnad för fordonsskatt per år | | |
| Hyreskostnad fordon | Total hyreskostnad per år | | |
| Leasingkostnad fordon | Total leasingkostnad per år | | |
| Avskrivningskostnad fordon | Total kostnad för avskrivning av fordon per år | | |
| Totalt utsläpp $CO_2$ | Total mängd utsläppt $CO_2$ per år | | |

# Appendix F - Value Stream Mapping Observation Protocol Test Case

| | |
|---|---|
| Company: | [Not disclosed] |
| Value flow: | Port of Göteborg |
| Date: | 2009-04-22 |
| Observer: | Emma Westerberg |

| Start | Stop | Process | Description | Photo |
|---|---|---|---|---|
| 13.21 | 13.22 | Handling | Exits the vehicle and tells what he wants to have loaded. | |
| 13.22 | 13.23 | Waiting | Waiting for information where to drive to get loaded. | |
| 13.23 | 13.24 | Handling | Drives to the loading station | |
| 13.24 | 13.24 | Handling | Exits the vehicle to loose the container. | |
| 13.24 | 13.25 | Handling | Loads one container. | |
| 13.25 | 13.25 | Handling | Moves the vehicle. | |
| 13.25 | 13.27 | Administration | Exits the vehicle to note which container. | |
| 13.27 | 13.42 | Transport | Drives to the Port of Göteborg, P4 Skandiahamnen. | |
| 13.42 | 13.43 | Administration | Takes a queing slip. We got number 307 and it is 267 now. | |
| 13.43 | 14.59 | Waiting | Waiting for our number. | |
| 14.59 | 14.59 | Administration | Drives to the check-in. | |
| 14.59 | 14.59 | Administration | Uses the entry card. | |
| 14.59 | 15.01 | Administration | Card doesn't work. Exits the vehicle. | |
| 15.01 | 15.01 | Administration | The card need to be renewed. | |
| 15.01 | 15.03 | Handling | Drives to the stop control. | |
| 15.03 | 15.09 | Administration | Exits the vehicle to register. | |
| 15.09 | 15.10 | Handling | Drives to the unloading slot. | |
| 15.10 | 15.27 | Waiting | Waiting for unloading. | |
| 15.27 | 15.28 | Handling | Unloading. | |
| 15.28 | 15.36 | Waiting | Waiting for loading. | |
| 15.36 | 15.37 | Handling | Loading. | |
| 15.37 | 15.39 | Administration | Exits the vehicle to give the plomb number to the administration. | |
| 15.39 | 15.40 | Handling | Drives out of the port. | |
| 15.40 | 15.40 | Administration | Check out. Uses the card. | |
| 15.40 | 16.02 | Transport | Drives back to the company's terminal. | |

# Appendix G - Value Stream Mapping Observation Protocol Validation Case

| Company: [Not disclosed] | | | | Date: 2009-05-20 | Trip meter start: 129970,1 |
|---|---|---|---|---|---|
| Driver: [Not disclosed] | | | | Observer: Rikard Larsson | Trip meter stop: 130059,9 |
| Value flow: [Not disclosed] | | | | Page: | Total kilometres: 90 |
| Start | Time | Process (T, H, A, Waiting) | Description | Waste in process | Address |
| 07:00 | 00:09 | A | Check in and gets the keys | | [Not disclosed] |
| 07:09 | 00:02 | A | Change spot on the truck and the car | | |
| 07:11 | 00:11 | T | Drives to terminal | | |
| 07:22 | 00:17 | A | Controls the pallets and get the orders | | [Not disclosed] |
| 07:39 | 00:06 | A | Check the addresses in the computer | | |
| 07:45 | 00:18 | H | Sorts the goods | | |
| 08:03 | 00:12 | A | Control the orders | | |
| 08:15 | 00:01 | H | Loading the goods on the truck | | |
| 08:16 | 00:07 | W | Reporting damaged goods | Waiting time up to 30 min | |
| 08:23 | 00:44 | H | Continues to load the truck | Puts plastic around a pallet | |
| 09:07 | 00:05 | A | Fills in the day list | | |
| 09:12 | 00:06 | A | Scans the orders | | |
| 09:18 | 00:15 | T | Drives to the first stop | | |
| 09:33 | 00:02 | H | Unloading | | [Not disclosed] |
| 09:35 | 00:01 | T | Drives to customer | | |
| 09:36 | 00:12 | H | Unloading | | [Not disclosed] |
| 09:48 | 00:04 | T | Drives to customer | | |
| 09:52 | 00:12 | Hx2 | Unloading | | [Not disclosed] |
| 10:04 | 00:03 | T | Drives to customer | | |
| 10:07 | 00:02 | W | Waiting | Waiting on a wrong parked car | |
| 10:09 | 00:09 | H | Unloading | | [Not disclosed] |
| 10:18 | 00:09 | T | Drives to customer | | |
| 10:27 | 00:06 | H | Unloading | | [Not disclosed] |
| 10:33 | 00:07 | T | Drives to customer | | |
| [Additional processes between 10:40-15:14] | | | | | |
| 15:14 | 00:06 | H | Loading the goods on the truck | | [Not disclosed] |
| 15:20 | 00:13 | T | Drives to terminal | | |
| 15:33 | 00:18 | T | Drives to terminal | Queues back to the office | |
| 15:51 | 00:19 | H | Unloading at terminal | | [Not disclosed] |
| 16:10 | 00:15 | A | Handling in day card | | |
| 16:18 | 00:22 | A | Handling in orders | | |
| 16:25 | 00:15 | T | Drives home to office | | |
| 16:40 | 00:10 | A | Change spot on the truck and the car | | [Not disclosed] |
| 16:50 | 00:10 | A | Check out | | |
| 17:00 | | | Working day is over | | |

# Appendix H - Order to Cash flow