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Analyzing the Value of Vehicle Maintenance Activities

Master of Science Thesis
in the Supply Chain Management Program

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ABSTRACT

This thesis work presents an analytical view of the value of maintenance activities from two main perspectives; the truck OEM and the transport providers. It is written related to one of the work packages of the "Efficient Maintenance for Sustainable Transport Solutions" (EMATS) project. Three main research questions of this study have been formulated around value of maintenance activities, definition and cost elements of poor maintenance and lastly the future expectations of actors regarding future transportation solutions. Therefore, the purpose of this master thesis is analyzing and increasing the value of maintenance from different perspectives through reduction in cost of poor maintenance and investigating future expectations of actors. When analyzing the value of maintenance activities, first of all information about maintenance management has been provided in theoretical framework in order to give an overview about maintenance to readers. Furthermore, business strategy and industrial marketing and purchasing theories have also been explained in order to have a better understanding about network approach and the relationship between the actors in a network. Finally as the core of this thesis work, value perception as a balance between the benefits and costs has been given in theoretical framework. The main theoretical contributions of this work are the creation and the increase of value along with the minimization of the cost of poor maintenance. The empirical data is gathered by interviewing experts in the field in each of the truck OEM and the transport provider sector. Together, the empirical data and the literature allow an analysis of the value of maintenance from the truck OEM's perspective, value of maintenance from the transport providers' perspective, a comparison of the two perspectives and the consequences for the truck OEM. A discussion is open to argue the feasibility of maintenance on new technologies, especially the electric vehicles, along with a discussion about the influences of other industries on the truck industry. In the conclusion of this study, the cost aspects that correspond to poor maintenance have been highlighted and recommendations have been given to reduce these costs in order to increase the value. Also, future expectations of actors have been evaluated. In addition to that, the value concept has been discussed from a holistic supply chain management perspective.

Contents

1. INTRODUCTION

This section provides information about the background, purpose, limitations and the research questions of this thesis work.

1.1 Background

Volvo Advance Technology and Research (ATR) at Volvo Group Trucks Technology (Volvo GTT) is a department that develops new technologies and concepts for hard and soft products and services within the vehicle and transport industry. The greater part of their success depends on their ability to constantly develop new innovative solutions which will increase safety and reduce environmental impact. Also, the group develops products and services that contribute to efficient transport and infrastructure solutions. Volvo GTT develops economic and efficient solutions for city distribution, long- haul, regional and construction purposes.

Volvo ATR together with Chalmers University of Technology, PostNord and Arho AB has an ongoing joint research project. The project is targeting one of the most important challenges for the future – sustainable transport solutions. In particular, this project will deal with the role of vehicle maintenance in sustainable transport solutions. Therefore, the name of the project is Efficient Maintenance for Sustainable Transport Solutions (EMATS). The EMATS project is co-financed by VINNOVA FFI (Fordonsstrategisk Forskning och Innovation) and will run during three years, 2015-2018.

The research project at large includes several work packages and issues related to different angles on this topic. In scope of this master thesis, the value of vehicle maintenance is analyzed, in terms of costs and benefits. It is examined from both the truck OEM and the transport providers' perspectives. In addition to that, the implications about current and future transportation solutions, along with an influence from other industries will be discussed.

Maintenance, as being considered as a crucial part of the success and image of the truck brands, is very important for the vehicle to operate at its optimum condition and thereby ensuring a consistent uptime of the vehicle throughout its life span. Many companies started realizing that if they wanted to manage maintenance effectively, they should include it in the general scheme of their organization and manage it with interaction with other functions (Crespo Márquez et al., 2009). When this is achieved, the importance that the maintenance deserves can be given and can also be developed as an additional function to the organization; with the purpose of generating products that satisfy internal clients and the fulfillment of some goals of the organization. Therefore, "the challenge of "designing" the ideal model to drive maintenance activities has become a research topic and a fundamental question to reach the effectiveness and efficiency of maintenance management and to fulfill enterprise objectives" (Crespo Márquez et al., 2009, p.168). The importance of maintenance to industry for Marais (2013) is about developing methods ensuring that maintenance resources are used efficiently, as they can be significant drivers of competitiveness or lack in case of mismanagement.

1.2 Purpose and Research Questions

As value is being defined based on the benefits created compared to the costs, the purpose of this master thesis is to analyze the value of vehicle maintenance in different solutions and contexts. It is focusing on the maintenance from two different perspectives: the truck OEM and the transport providers; and covers the cost structures and the cost of poor maintenance in more depth. This thesis mainly covers the maintenance activities in today's situation, however

the implications about maintenance operations of possible future transport solutions are also provided. In more details, it deals with these research questions:

- How can the benefits and cost be balanced in order to generate the highest value for maintenance activities, from the perspectives of the truck OEM and transport providers?
- What does poor maintenance mean from the perspectives of the truck OEM and the transport providers, and what are the cost elements of poor maintenance today?
- What do the truck OEM and transport providers expect from the maintenance activities in the future?

Therefore, the expected results of this master thesis can be listed as investigating the cost structures for different actors, evaluating the value for different actors when incurring to the specific cost, figuring out the cost of poor maintenance and also identifying the future needs for maintenance operations.

Given the complexity of this master thesis, this study will only focus on the vehicle maintenance and the grounds for value, benefits and costs taken from the perspectives of the truck OEM and the transport provider. Also, the cost structure and poor maintenance will be taken into account. Due to time limitation, the study will focus on current existing vehicle technologies and mainly investigate cases where the transport provider outsources the vehicle maintenance to the truck OEM. The thesis will also include a discussion regarding implications for future sustainable transport solutions. In addition to that, it will not cover the operations at sites or involving construction vehicles, but will rather focus on the freight and cargo, i.e. long haul, regional transports and distribution. Finally, the thesis will be geographically limited to Sweden.

1.3 Thesis Structure

The structure of this thesis work is explained below in table 1.

Table 1: Structure of the thesis

Theoretical Framework	This section includes all the literature needed for this work and which sections have been selected based on their relevance to the topic. These areas are: Maintenance management, Industrial marketing, purchasing and business strategy, and Value Creation. Finally a framework for analyzing the value of maintenance was presented.
Methodology	This part explains how this thesis work was elaborated, by explaining how literature and empirical data are combined and how the empirical data was selected. It also emphasizes on the strategy used for this work
Empirical Data	This section represents all the interviews that were held with persons within the truck OEM, the transport providers, and other industries.
Analysis	In this section, a combination of the literature and the empirical data was made in order to give an analysis of the value from the perspective of the truck OEM and transport providers, also to compare the two perspectives and to finally analyze the consequences for the truck OEM.

Discussion	This section represents a discussion about how the other industries, as aircraft and railway, influence the truck OEM; in addition to that, it contains a discussion about how the maintenance might look like in the future with new technologies.
Conclusion	This section provides a conclusion of the thesis work

2. THEORETICAL FRAMEWORK

As this section is about creating a foundation of what the thesis will be dealing with, it is important to introduce primarily three main topics that are: Maintenance management, Industrial marketing and purchasing (IMP) and value creation.

2.1 Maintenance Management

In the last three decades, companies have admitted that in order to manage maintenance operations appropriately, the perspective of maintenance should be included in the business model of the organization and interact with the different functions (Crespo Marquez et al., 2009). Only after achieving this, maintenance could be considered as an important aspect for the company and be developed as a different function in the organization, which contributes to the achievement of business goals of the organization. This has led researchers to develop new research topics which are designing the ideal model to manage maintenance operations and also achieving efficiency and effectiveness of maintenance management (Crespo Marquez et al., 2009). In order to manage maintenance, many different steps, sequences of activities or the best practices have been proposed by different authors in the history. The maintenance management model which has been developed by Crespo Marquez et al. (2009), will be applied in this study combines other models that have been found in the literature and includes eight sequential building blocks.

2.1.1 The Maintenance Management Process

According to Crespo Marquez et al. (2009), the maintenance management could be examined in two different parts which are the definition of the strategy and the strategy implementation. Definition of the maintenance objectives is considered as an input for the definition of strategy part and this maintenance objectives definition will be generated directly from the business plan. This first part actually determines the success of maintenance in the organization and the effectiveness of the implementation part later on. Here, effectiveness is defined as an indicator which expresses how well a function meets its goals regarding service quality from the customer's perspective. A reliable definition of maintenance objectives, thus, leads to reduce the indirect maintenance costs which are the costs related to the customer dissatisfaction and production losses. Effectiveness can also indicate the reduction of overall company cost and the overall company satisfaction (Crespo Marquez et al., 2009).

The second part of maintenance management has been defined as the implementation of the selected strategy. In order to reduce the direct maintenance cost, the ability of the management team to deal with the maintenance management implementation problem should be high. On the implementation part, efficiency is taken into consideration more than effectiveness. And efficiency is defined by Crespo Marquez et al. (2009) as producing with minimum expense and waste and also unnecessary effort. With the other words, efficiency can also be interpreted as being able to provide the same or better maintenance for the same cost. In the following section, the generic maintenance management model will be provided in Figure 1 with eight building blocks. The first three building blocks determine maintenance effectiveness while the fourth and fifth ones condition maintenance efficiency. The block six and seven stand for maintenance and assets life cycle cost assessment and finally the eighth block is devoted to continuous maintenance management improvement (Crespo Marquez et al., 2009).

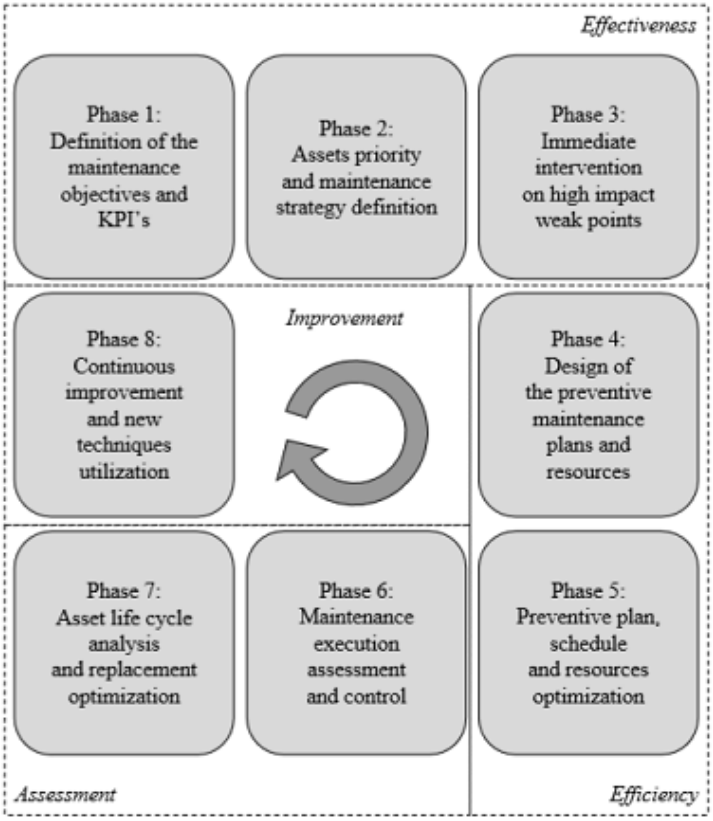

Figure 1: Maintenance Management Model (Source: Crespo Marquez et al., 2009, p.169)

2.1.2 Maintenance Management Framework

This section includes the brief definition of each building block and discussion of methods that are beneficial to improve decision-making process for each building block as it is given in Figure 2. In Phase 1, the definition of the maintenance objectives and KPI's are taken into consideration. In this phase, it is usually observed that operational strategy and the operational objectives are not totally consistent with the overall business strategy (Crespo Marquez et al., 2009). In order to avoid from this problem, according to Kaplan and Norton (1992), the balanced score card (BSC) should be introduced to the system. Normally, the BSC is designed specifically for each organization and it ensures to create KPI's to measure the performance of maintenance management which are beneficial to achieve the strategic objectives of the organization.

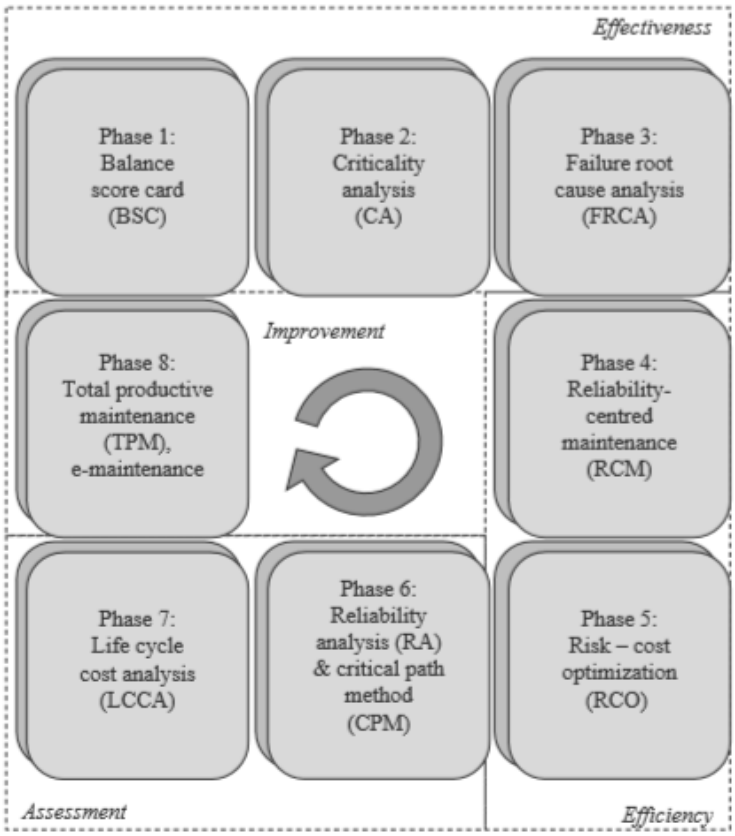

Figure 2: Sample of Techniques within the Maintenance Management Framework (Source: Crespo Marquez et al., 2009, p.170)

After defining the maintenance objectives and strategy, in the Phase 2, number of qualitative and quantitative methods can be used in order to identify which assets deserve the priority in a maintenance management process. One of the most useful techniques is known as the "Probability/Risk Number" – PRN (Moubray, 1997), and most of the quantitative techniques have been developed from this concept. The concept suggests that firstly, the assets with higher PRN values should be evaluated. Prioritizing assets is followed by Phase 3 which is developing particular maintenance actions for each category of assets. And in this phase, in order to develop specific maintenance actions, the repetitive failures in highly prioritized items should be identified. After finding the causes of these failures, immediate intervention is also performed in this phase.

In Phase 4, the preventive maintenance plan should be designed, however, in order to perform this; firstly the functions of a certain system and how these functions could fail have to be identified. Only after that effective and applicable preventive maintenance tasks could be established to ensure system safety. After designing the preventive maintenance plan, in Phase 5, maintenance plan and schedule should be optimized in order to increase efficiency and effectiveness of the initial plan which comes from phase 4. The Phase 6 includes the execution of maintenance activities. When designing, planning and scheduling are performed in the previous building blocks, in this phase, the outcomes from the first four building blocks have to be evaluated and also deviations should be controlled in order to achieve business goals and reach to the values that have been determined by the organization for the key maintenance performance indicators. In the Phase 7, the life cycle cost analysis should be made. And this analysis basically reveals the cost of a particular asset for its life time. This analysis can include different types of cost elements, such as costs for research and

development, operation, disposal, planning, production and maintenance. According to the literature, the life cycle cost analysis has three main advantages for the companies during the decision making processes (Crespo Marquez et al., 2009):

1. The life cycle cost analysis makes all the costs for a specific asset visible.
2. It helps to analyze interrelationships between the functions. For instance; decreasing the R&D cost can influence the quality and cause to have high maintenance costs.
3. Since it helps to have more reliable cost calculations, it also allows managers to have revenue predictions more accurately.

As the final building block, continuous improvement of maintenance comes in Phase 8. In order to perform continuous improvement, all the possible methods and technologies should be used on the processes that have high influence on the building blocks of the management process (Crespo Marquez et al., 2009).

2.1.3 Poor Maintenance

According to Salonen and Deleryd (2011), cost of maintenance in Sweden has been estimated to be close to 200 billion SEK per year and is constituting of 6.2% of the industry's turnover. However, one third of this cost is spent unnecessarily on bad planning, overtime costs, bad use of preventive maintenance, etc. Therefore, cost of poor maintenance CoPM, will be introduced as a means that helps improving maintenance performance.

In order to discuss the financial aspects of maintenance in this thesis, it will be related to the financial aspects of quality. Quality has been managed and achieved through inspections and sampling schemes until it has been shown that this approach is very costly and therefore many discussions about quality and cost started raising. Then, over the years more studies showed that its not quality that is costly but rather the lack of quality, and that is the reason why today cost of poor quality CoPQ is mentioned more than cost of quality. CoPQ has been defined as costs that could have been eliminated if the company's products and processes were perfect, or as being the total losses coming from imperfect products and processes of a company. So, inspired from the concept of CoPQ, CoPM will be described and the CoPQ concept will be a driver to use in setting and justifying maintenance strategies (Salonen and Deleryd, 2011).

There are three applications of CoPQ as a measure to:

> "(1) increase the awareness of the implications of quality improvements among the managers and employees;
> (2) identify and prioritize among different problem areas; and
> (3) follow up and evaluate the outcome of the quality improvement actions." (Sörqvist, 1998, p.65).

And therefore, in accordance with the previous applications of CoPQ as a measure, these three can be used for CoPM as a measure:

> "(1) Increase the awareness of the implications of maintenance improvements among the managers and employees.
> (2) Identify and prioritize among different problem areas; and
> (3) Follow up and evaluate the outcome of the maintenance improvement actions." (Salonen and Deleryd, 2011, p.67).

Maintenance is performed either for prevention, or for correction. Both of the types may relate to either costs of conformance or costs of non-conformance. Therefore a matrix can be

set with both corrective and preventive maintenance in relation to cost of conformance and non-conformance.

	Corrective maintenance	Preventive maintenance
Cost of Conformance	Indispensable corrective maintenance: Corrective Maintenance due to: - Failures with random distribution and no measurable deterioration - Failures which are not financially justified to prevent	Valid preventive maintenance: Preventive Maintenance, necessary to uphold necessary dependability Improvements intended to increase the reliability of equipment
Cost of Non-conformance	Non-accepted corrective maintenance: Corrective Maintenance due to: - Lack of preventive maintenance - Poorly performed preventive maintenance - Poor equipment reliability	Poor preventive maintenance: Unnecessary Preventive Maintenance Poorly performed Preventive Maintenance

Figure 3: corrective and preventive maintenance divided into conformance and non-conformance costs (Source: Salonen and Deleryd, 2011, p.68)

From figure 3, four categories of costs are identified:
(1) costs for indispensable corrective maintenance;
(2) costs for valid preventive maintenance;
(3) costs for non-accepted corrective maintenance; and
(4) costs for poor preventive maintenance.

To distinguish between conformance and non-conformance costs, cost of conformance is mainly associated with preventive maintenance and some corrective maintenance that are accepted by the organization; while, non-conformance is connected to corrective maintenance, as well as some preventive maintenance as mentioned in figure 3 (Salonen and Deleryd, 2011).

Figure 4 shows the expected outcome from using the concept of CoPM in order to identify weaknesses in the maintenance performance, and optimizing the actions and costs of conformance, reduce the waste of non-conformance, and therefore the total cost (Salonen and Deleryd, 2011).

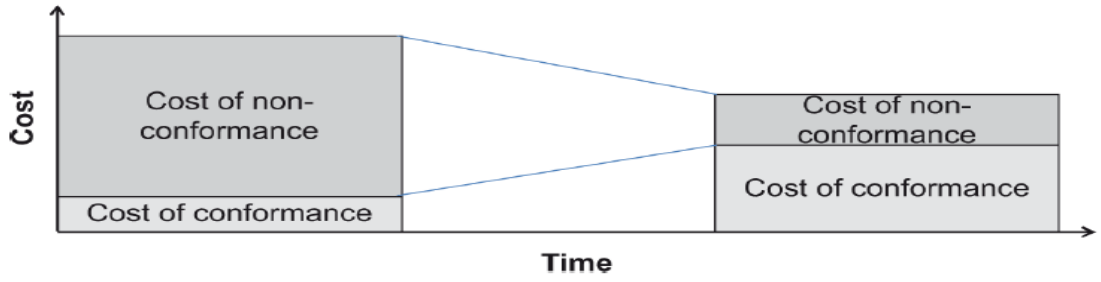

Figure 4: Expected outcome from the use of CoPM concept (Source: Salonen and Deleryd, 2011, p.70)

2.2 Industrial Marketing and Purchasing and Business Strategy

In the recent twenty years, it can be seen that two important trends have emerged in business organization studies. First trend can be defined as a growing interest for business strategy and how a business strategy can be managed. And the second trend is performing a shift in terms of organizational theory and this shift leads from focusing on mostly the internal processes of the organization to focusing on the organization-environment interface (Håkansson and Snehota, 1989). In order to have a better understanding about organizational behaviors, both trends have been helpful for the researchers. However, there is a contrast between these two trends. While organizational theory researches focus on the relationship between an organization and its environment and how the organization is actually embedded in its environment thus it is not independent and cannot survive alone, the strategy management studies mainly focus on the organization individually and assume that the organization has a degree of freedom in its environment. This perspective difference between the trends does not allow taking advantage of them at the same time (Håkansson and Snehota, 1989). In the following sections, some assumptions for strategy management will be examined, and then three main issues of the strategy management principle will be discussed from the network model of the organization-environment interface perspective, which are; organizational boundaries, organizational effectiveness and the business strategy management process.

2.2.1 The Concept of Business Strategy

The business strategy management concept includes many different approaches from different research areas, such as industrial economy, organizational theory and management theory and consultancy, which make it quite hard to grasp a frame for business strategy management. Since these are not completely related to each other, the link between the approaches could only be loose in the business strategy management doctrine. In the military concept, strategy means "the art of so moving and disposing troops as to impose upon the enemy the place and time and conditions for the fighting preferred by oneself" (Oxford English Dictionary). However, it is quite difficult to allocate resources in space and time, since the resources of business organizations are generally fixed in time and place (Håkansson and Snehota, 1989). In the literature there are numbers of definitions for the strategy concept, however they all meet at the same point as "the pattern in the stream of decisions and activities… (Mintzberg and McHugh, 1985, p. 6)… that characterizes the match an organization achieves with its environment… and that is determinant for the attainment of its goal…" (Håkansson and Snehota, 1989, p.188). In other words, strategy is a pattern of activities that allows achieving organizational goals while matching organization with its environment. Business strategy studies firstly focus on understanding what makes the organization effective and then how to increase this effectiveness in its environment. The general assumption about effectiveness is that, the accumulation of wealth shows how the organization is effective in its environment. In this sense, the accumulation of organizational resources is considered as being "vital" for the organization (Håkansson and Snehota, 1989). However, only the wealth is not considered well enough for organization to survive, nowadays.

The idea of "survival of the fittest" which has been derived from biology applies in strategy management as well. Organizational effectiveness is defined as a function which matches the capabilities of the organization with the characteristics of the environment. The main idea of the strategy management principle is achieving a fit between the characteristics of the environment and the capabilities of the organization. If the organization can perform better than the other organizations in terms of competing for the resources in the environment, then the "fit" with the environment is considered to be good. "Performing better than the others" usually means offering "superior value" to the organization's stakeholders (Håkansson and

Snehota, 1989). Here, the "superior value" transforms inputs into outputs in the way that the efficiency is maximized. Strategy management is the process of matching the external environment with the conditions of the organization. On the other hand, managing strategy is managing how the activities that will be performed by the organization are understood (i.e. strategy formulation) and also how the conditions could be created in order to perform these activities (i.e. strategy implementation). In strategy management principle, when it comes to adapting the capabilities of the organization to the external environment, there are three main assumptions. The first assumption is that, the environment is atomistic and faceless; therefore it cannot be kept under control by the organization. This also means that the opportunities are created by the environment and they exist in the environment. The organization can only identify and exploit the opportunities in the environment by adapting itself. It is not possible for organization to create opportunities in its environment and the environment does not need the organization in order to exist. The second assumption is that the deployment of organizational resources shows how the strategy of an organization is framed. The resource allocation is made by the organization in order to provide services or products to its environment. And the last assumption is that the environment is dynamic and continuously changing. Therefore the organization has to be able to follow the changes and adapt to its environment in different conditions (Håkansson and Snehota, 1989).

2.2.2 Strategizing

Industrial network approach is a strategy management approach that considers how the firms that have interconnected business relationships with the other firms operate in a specific environment. In strategic perspective, the relationships between firms are crucial since they affect the firms' actions and also the efficiency and effectiveness of their potential resources (Gadde et al., 2003). In this sense, strategizing concept has been created in order to identify the scope of a particular action within existing and potential relationships and to operate with the highest effectiveness with the other firms without exceeding the constraints that limit the scope (Gadde et al., 2003).

In the literature, it has been stated that strategy has five different core aspects which are the purpose, organization, competitive performance of the firms, strategic leadership and direction (Gadde et al., 2003). It has been a common belief that industrial network approach has been affected by strategy management doctrine. However, in recent studies it has been seen that strategy management theory has also been offered some insights by industrial network thinking. In the following sections, the main strategic issues will be stated and then they will be discussed based on the three basic network dimensions which are actors, activities and resources.

- **The Main Strategic Issues of an Industrial Network**

In the traditional perspective, strategic actions only consider the efforts by only one actor that affect the relationships of a firm with its environment. However, in industrial network perspective, strategic action concerns the efforts that define where the firm stands in its environment with the actors (Gadde et al., 2003). Industrial network approach also states that the interdependence between actors is an important aspect rather than having a competitive relationship with actors. The recent studies also reveal that building and maintaining relationships between actors should be the core of strategy, since firms do not exist independently in their environments (Gadde et al., 2003). According to Ford et al. (1998), the perception of strategy changes into succeeding the tasks together with suppliers, distributors, customers and development partners from having a victory over the other actors, where the relationships are built interdependently.

When it comes to discussing strategic issues in industrial networks, according to Håkansson and Ford (2002), there are three main paradoxes in the networks which should be explored carefully in order to have a better understanding about strategic issues. The first issue derives from the paradox of having close relationships between the firms. The fact is that close relationships are crucial for the firms to survive in their industrial network since the resources are shared through these relationships. However, on the other hand, a high level of interdependency might also restrict the firms' ability to change their way of operating and thus developing. Therefore, the first issue for strategizing can be defined as how to identify a reasonable and beneficial level of involvement within the relationships with other actors in the environment (Gadde et al., 2003). Another paradox is derives from the fact that the relationships of a firm can be considered as an important tool to influence the other actors in the network. Since the relationships are reciprocal in the network approach, this means the firms can also be influenced by the other firms' actions as well as they can influence them. Therefore, the second issue for industrial networks is about how to balance the interplay between being influenced by the other actors and actually being the one that influences the others (Gadde et al., 2003). And the third paradox is derived from the fact that firms tend to control the other actors in the network in order to achieve their goals. Here, the paradox is that when the firms become more successful at controlling their network, the network actually becomes less innovative and less flexible against changes. With the other words, the network might face the risk of being less developed. Therefore, the third issue for industrial networks is how to identify the appropriate level of ambition for control (Gadde et al., 2003). In order to overcome these three main issues, it is recommended in the literature that firms should apply strategic orientation based on three network dimensions which are resources, activities and actors (Gadde et al., 2003). The issue that addresses the appropriate level of involvement is related to the resource dimension while the issue that concerns being influenced and influencing the other actors is more related to the activity dimension. And finally, the issue about controlling the network is found related to the actor dimension.

- **The Resource Dimension**

The industrial network approach assumes that the existence of business relationships has a significant importance. And strategic resources are represented in three different ways by these relationships between suppliers, customers and the other actors. First of all, the relationships are important for the firm itself, since the quality of the relationships will eventually affect the sales and procurement in the company. On the other hand, the relationships have high importance when achieving the technical development, since the firms tend to rely on their relationships with each other during the development process. The second way to represent resources can be explained by using the direct relationships that a firm has. A focal company is connected with its network through the direct relationships that it has with the other actors. Therefore, direct relationships are considered as a reflector of firms' resources rather than being only a bridge between the firms. And lastly, the organizational and physical resources of a firm are combined with the other firms' resources through the relationships. This means, some certain amount of a firm's resources should be shared with its counterparts and controlled bilaterally.

Resources can be used more than once, and also combined with some other resources in many different ways. Some of the features can be unutilized while the some features are exploited when using the resources for a particular purpose. One way to increase utilization of the resources is considered as developing relationships between the firms. In this sense, in order to develop better relationships, the firms should increase the level of involvement, however high level of involvement is also more costly and require more investment for the firms. On

the other hand, high level involvements also bring firms the risk of being too much interdependent to each other (Gadde et al., 2003).

- **The Activity Dimension**

The firms interact with each other by exchanging services or products and during the interaction, the organization of the flow of goods and information is always matters of concern for the firms. In an industrial network, the activities that organize these interactions are considered interdependent and linked to each other either strongly or loosely. And these links between activities are considered quite valuable and useful since the links give firms the chance of operating beyond their ownership boundaries.

In network approach, activities of firms are considered as a part of the whole network and quite interdependent with the activities of other firms rather than being isolated from the network. Hence, the way that interdependencies are handled is very important since they affect the efficiency and effectiveness directly. When it comes to handling interdependencies, it can be said that each firm has its own principles about in which level the firm should be dependent to its counterparts. In this sense, firms tend to differentiate their counterparts based on their importance level and apply different pattern of interdependency for each counterpart. Consequently, the productivity of a firm is related to the coordination of its activities with those of other firms, the industrial network approach emphasizes the importance of building interdependencies systematically (Gadde et al., 2003).

- **The Actor Dimension**

According to the industrial network thinking, networks are dynamic systems that change in time with no certain borders and also the actors are loosely connected to each other in the networks and no actor can dominate the network (Wilkinson & Young, 2002). However, when it comes to network development, even though the actors are loosely linked to each other, the overall network logic affects the actors. In this sense, actors often have to coordinate and combine their activities and resources. Since, the actors tend to compete and influence each other in order to achieve their business goals, combining and coordinating the resources and activities becomes challenging most of the times. According to the literature, when an actor try influence another one, it actually increases the development potential hence, being able to influence and control the other actors is one of the most important drivers of network dynamics. Nonetheless, the ambition of influencing and controlling the other actors also brings the risk of having a less effective network in the long future and the network will not be able to respond future changes anymore (Gadde et al., 2003).

2.3 Value Creation

The definition of value remains ambiguous since many articles have different ways of explaining the meaning of value. However, there are similarities between all the definitions in a way that value consists of both positive and negative sides.

2.3.1 Definition of Value

According to Christopher and Gattorna (2005), the most markets are price competitive today compare to what they used to be years ago. In most of the western countries, prices tend to decrease in shopping malls and high streets which cause a price reduction in raw materials, industrial products and components. Studies also prove that customers have become more value conscious than they were before (Christopher and Gattorna, 2005). And this means the manufacturers that could set premium prices for their products by using their reputation in the market cannot follow the same strategy anymore, since there are other alternative companies

that can offer the same value with a lower price. Therefore, if companies want to sustain their financial and operational performance, they have to take their customers' cultural capabilities, strategies and leadership styles into account when they create value for their customers. And the starting point to be aligned with customers has been discussed as being able to interpret the marketplace and going beyond economic concepts into the world of human behaviors (Christopher and Gattorna, 2005). Costa (2014) on the other hand, discussed value engineering as being a systematic method that helps improving the value of a product or a service by examining their functionalities. However, the concept of value, benefits and cost can vary depending on the interlocutor and interpreting them wrong can lead to undermining the whole business value engineering effort. In that sense a common mistake that firms do is to jump into the process assuming that the concept of value is clear and need no further attention.

For Costa (2014), value can be defined as the difference between benefits and the costs as figure 5 shows, and that the purpose of each firm is to maximize the benefit and to minimize the cost. However, attention should also be giving to the fact that maximizing the benefit is not the only way to add value and that cost is equally important.

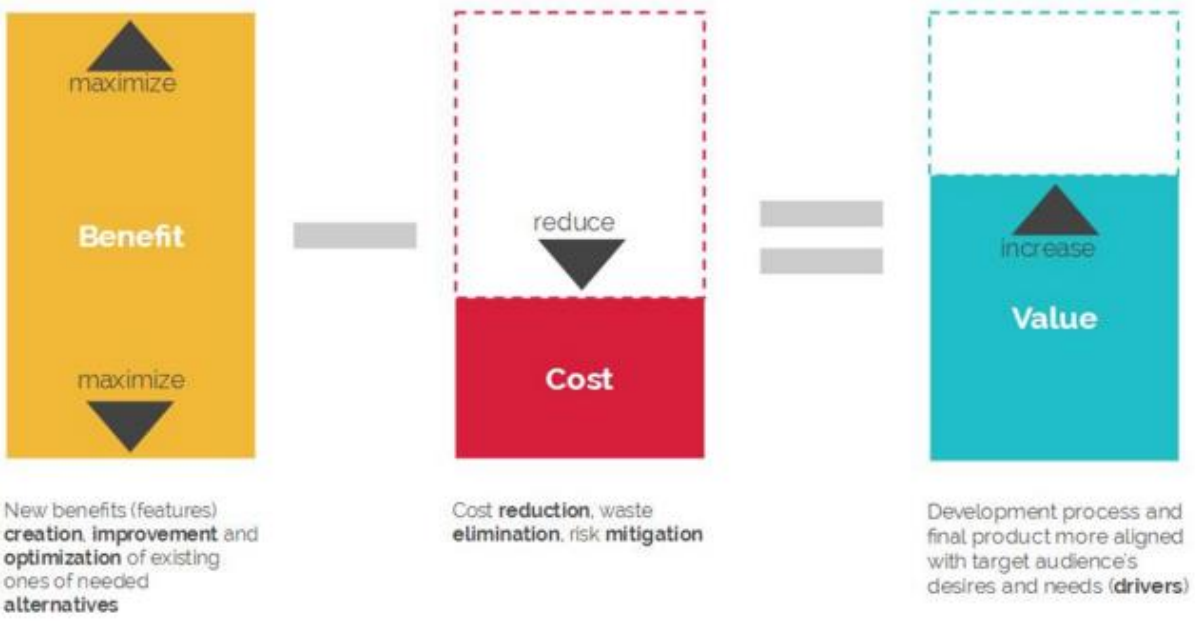

Figure 5: Definition of value regarding benefit and cost (Source: Costa, 2014[1])

Even if many organizations believe that creating new benefits generate value, as adding new features to a product for instance, there are many opportunities to increase value on existing products or services without necessarily adding any new features. These opportunities generally include: refactoring a process on the purpose of reducing complexity or duration, simplifying an existing feature to improve the engagement of the customer, consolidating, reducing infrastructure costs, etc. So, it is very important to increase the stakeholders' awareness of both benefit and cost components of value and to educate them regarding the many options available to maximize profit and reduce cost. Therefore, in this thesis, the focus will be related to benefit and cost regarding both and non- aspects, as they are the two dimensions that value consists of.

[1] https://www.linkedin.com/pulse/20140819183644-881635-business-value-engineering-framework

More specifically and from the perspective of maintenance, Marais (2013) discussed whether the reliability acquired through maintenance is "worth" its cost but which is usually not addressed, partly due to the difficulty to do so. Whether the output of maintenance management is produced effectively in terms of profits is not easy to answer. Therefore "maintenance planning is usually shifted from a value maximization problem formulation to a cost minimization problem" (Marais, 2013, p.77). Maintenance then is often a significant component of any firm's operating costs. Therefore, this can allow a way of quantifying the return on this investment, or so called "value of maintenance".

2.3.2 The Perception of Value

Let's take the example of a two guys and the same motorcycle shown in figure 6. For the same motorcycle with same price, features, maintenance cost and risk, these two guys have different perception about its value. When considering the first guy, he believes that buying this motorcycle has no value at all since his priorities are safety and comfort for him and for his family. So for this guy the cost of the motorcycle exceeds and his budget to support his family exceeds the benefits. While for the second guy, the same motorcycle has great value. This guy is mainly looking for adventure and is motivated by the sense of freedom and do not have any to support family. So, the benefit this motorcycle provides exceeds its cost and therefore is a perfect match for him (Costa, 2014).

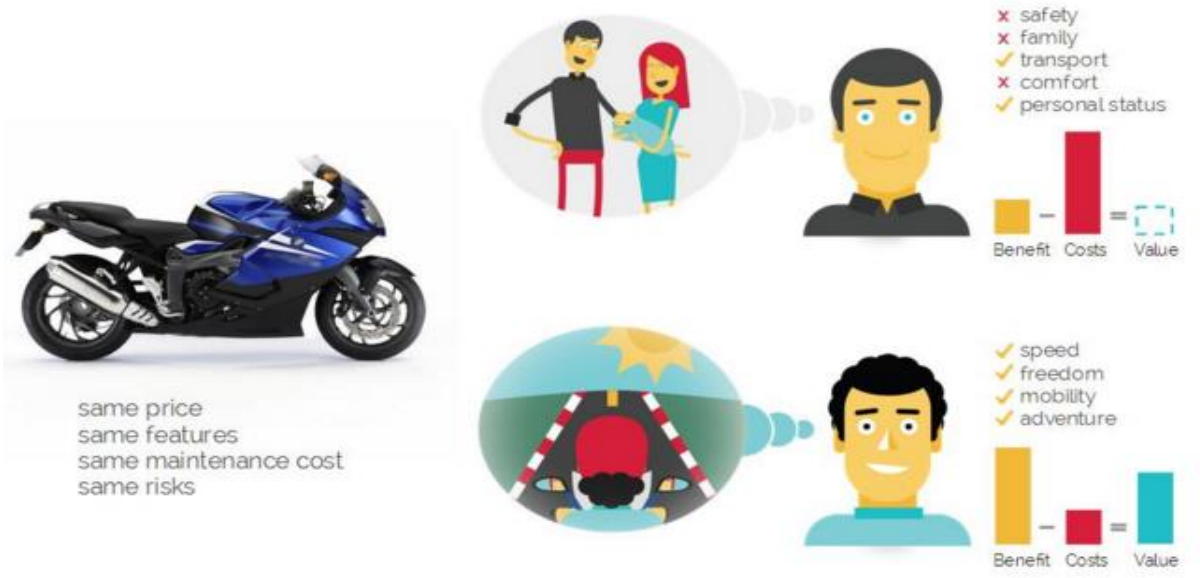

Figure 6: Two different perspectives about the same product (Source: Costa, 2014[2])

Bringing such concepts to this business case, for Costa (2014) it is vital to first of all think about whose perception of value is needed to be captured. And if the project is targeted externally, this is important to understand the customers and consider their perception of value when evaluating the features; whether they need mobility, or if they are more interested in quality rather than the price; or where they are concentrated geographically and even if there is any cultural aspect to be considered (Christopher and Gattorna, 2005; Costa, 2014).

[2] https://www.linkedin.com/pulse/20140819183644-881635-business-value-engineering-framework

2.4 Framework for Analyzing the Value of Maintenance

The purpose and research questions of this master thesis focuses on cost, value, poor maintenance and future expectations regarding maintenance operations. In order to reach to the purpose and answer the questions, the following related concepts are used and this section is provided to explain how the chosen concepts are related to the research topic.

The first concept that is given in theoretical framework is maintenance management doctrine. The definition of maintenance management, the maintenance management process and a framework for maintenance management have been provided to the readers in order to give a better understanding about the overall concept and also how important the maintenance management is. After that IMP and business strategy concepts are given in theoretical framework. Since the concepts provide a new perspective about "survival of the fittest" and the importance of "the match between the characteristics of the environment and the capabilities of the organization" rather than the traditional perspective of "performing better than others", they are considered to be useful when it comes to new value creation based on the actors' future expectations. The following concept has been chosen as strategizing and this concept has been found helpful through the three main strategic issues that it states. The concept also discusses about the reasons and also the recommendations to minimize the risk of having these particular issues. Therefore, in terms of value creation, it has been considered that taking these main issues into consideration and discussing about how to mitigate the risk of facing them would increase the value of this thesis work.

The next concept is given as the concept of value creation. Increasing the value of the maintenance activities is considered as the core section of this research. Value is considered as the difference between benefits and cost (Value = Benefit – Cost). Therefore, to increase the value, firms should consider balancing the benefit and the cost and try to maximize the benefits while minimizing the cost (Costa, 2014). It is also possible to increase the cost in some cases where the benefits generated are higher than the cost itself for instance. In addition to that, the monetary cost section of this equation will be studied in more depth. It will cover the cost elements along with the cost that poor maintenance might generate, in both the corrective or preventive maintenance, and that are mainly not accepted by the organizations. Maintenance that is not accepted by the organizations is called non-conformance cost, while the cost of conformance is valid to have by the organizations (Salonen and Deleryd, 2011). Therefore, while trying to minimize the overall cost, cost of non-conformance should also be minimized. Figure 7 shows how value is perceived as the difference between the benefits and the cost.

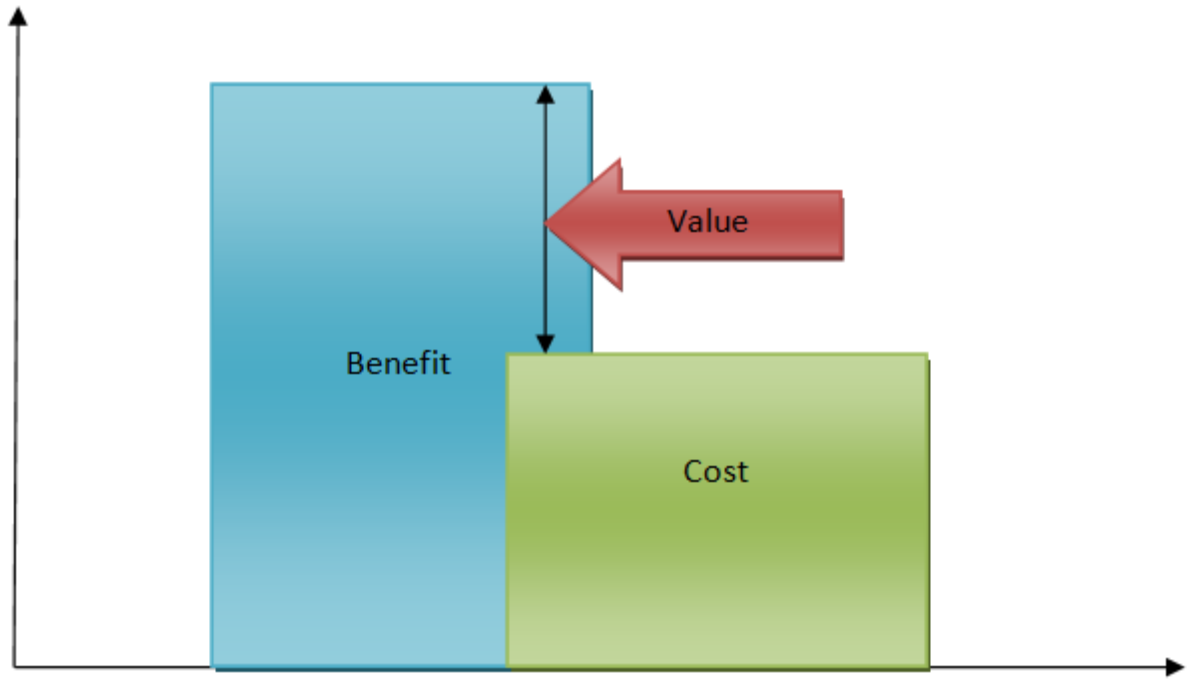

Figure 7: Value as being the difference between the benefit and the cost

3. METHODOLOGY

This section represents how this thesis work was elaborated and what strategy and principles have been chosen in order to do so. Firstly, the primary data was collected by interviews that were held with persons occupying different positions in the truck OEM and the transport providers. This has been done in order to get different perspectives and understand how the value for one actor in the chain can affect the value of the other one. In addition to that, the reason why the transport providers companies were selected for the interviews is that they are the leading companies in their market. In addition to that, interviews were also conducted with persons working in other industries and were chosen based on how much their maintenance activities can affect and increase the truck OEM's maintenance activities. The interview questionnaires are presented in the Appendix I. The secondary data was held through the literature review focusing on the main areas that corresponds to this thesis work. The primary data was then combined with the secondary data in the analysis section in order to give an outcome that is concluded with presentation of the findings and discussion of implications. Systematic combining approach was the main principle that this thesis work was based on and that will be explained more in the following section.

3.1 Process of the Thesis

This thesis work is the result of five months of research and study. In the beginning of the process, the authors have started writing the project description and planning report for the first three weeks along with literature review at the same time. After that, the interviews have been arranged and conducted with responsible persons in the truck OEM and transport provider. However, when gathering the empirical data, literature review and methodology have also been developed based on the findings from interviews. In the 6th week, empirical data has started to be analyzed based on theoretical concepts and as long as a new data has been introduced to the research, the analysis has been developed for fifteen weeks. At the end of the period, the analysis and findings have been concluded in the 20th week.

The figure 8 below shows the time plan that has been followed during this whole thesis work, including the phases and the timeline.

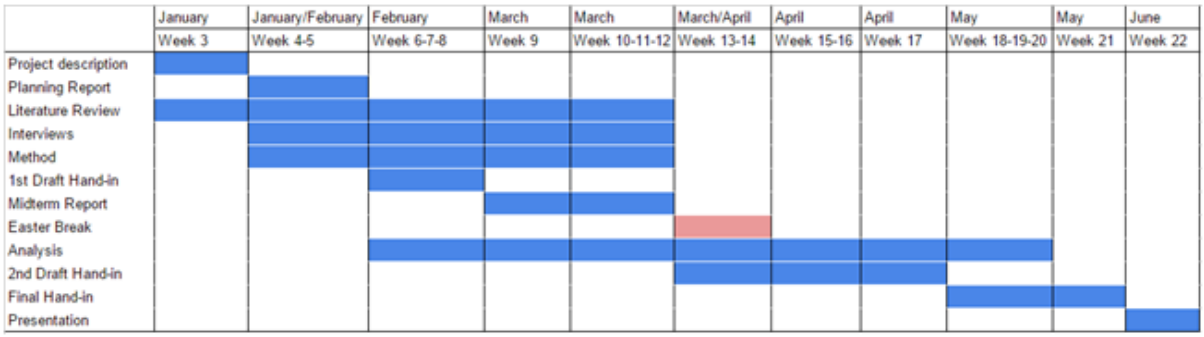

Figure 8: Gantt for the phases of this thesis work

3.2 Data Collection

This section includes a description of how the data of this thesis work has been gathered. For primary data, it has been collected from interviews within different companies; while the secondary data was gathered from the literature section which consists of different topics, and that along with primary data make a good fit for the findings of this thesis work.

3.2.1 Conducting Interviews

Primary data is collected from interviews which were conducted with people with different positions inside of the truck OEM. Also, with other actors in the network as transport providers and one dealer; in other words, the truck OEM's customers or future probable customers. In addition to that, interviews were held with persons from other industries, as railway and aircraft, and that are related to the maintenance field, in order to investigate whether it is feasible to adapt some features of the maintenance activities to the truck industry.

Four interviews have been held within the truck OEM and for which some had more than one interviewee. One interview has been held with one dealer and that in this case is considered as part of the truck OEM. Other interviews were held with representatives from the aircraft industry, railway industry and three transport providers. Table 2 shows all the interviewees' positions along with the companies.

Table 2: Interviews along with their positions in companies

Perspective	**Position**
Truck OEM	Vice president global product planning, aftermarket and product related services
	Feature Specialist Transport Effectiveness, Product Planning
	Feature specialist maintainability and uptime
	Maintainability transport research manager
	Director, Technical Aftermarket
	Director service sales
	Director automation service and customer support
	Business Developer Soft Products
Truck OEM/dealer	CEO and Workshop Manager
Other Industries	Aircraft engineer, responsible of the hangar
	Product Planning Manager Ex. Responsible for the maintenance optimization for trains
Transport provider	Responsible for Innovation, Improvement and Operational Coordination between Transport Provider C's 30 Ports & Terminals across Europe
	Head of the fleet in Transport Provider B and Responsible for heavy vehicles and forklifts
	Managing Director in Transport Provider A

3.2.2 Literature Review

This secondary data consists of the literature gathered in the scope of this thesis work. It can be divided into 3 main sections that are: Maintenance management, industrial marketing and purchasing and business strategy, and value creation. These three sections have been analyzed further in the analysis section and some concepts have been used as basis for the findings. Maintenance management, especially the section of poor maintenance, along with the value creation section has been the core of this thesis. Therefore, the findings of this thesis are mainly based on cost of poor maintenance and value maximization. In addition to that, the section of industrial marketing and business purchasing, more specifically strategizing is used for introducing two paradoxes in the discussion part.

3.3 Capturing Perspectives in a Transport Network

In order to understand the actors involved in this thesis, graph 9 includes a representation of the different parties along with how they are related to each other in the network. The actors that this work will focus on are mainly the truck OEM and transport providers, and the reason is that the transport providers are considered the main customers of the truck OEM. The transport buyers and the dealers are also part of the network but will not be part of this thesis work analysis. The dealer is considered as a part of the truck OEM based on the tight agreement between the two actors and therefore, it will not be studied as a different perspective. In addition to that, due time limitation, transport buyers have also been excluded from this thesis work. A transport provider can work with many dealers and have many transport buyers, while a transport buyer can buy the transport service from the transport provider or from the truck OEM directly and therefore deals with the truck dealer directly.

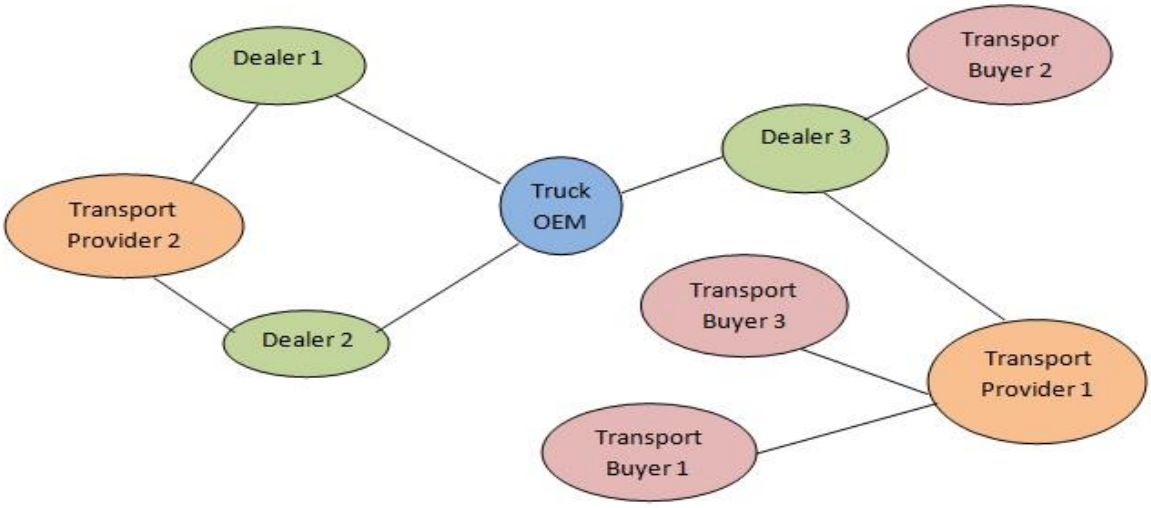

Figure 9: Network of the Actors

3.3 Quality of the Research

Regarding quality of the research, Golafshani (2003) argues that it is quite difficult to have a high level of validity and reliability in qualitative researches. It has also been discussed by Stenbacka (2001) that the concept of reliability might actually be leading a qualitative study to a "low level of quality" since the technics for reliability require some certain measurements, which is irrelevant and not applicable for a qualitative research.

However, in order to make the research more reliable, *"triangulation"* approach has been proposed by Lincoln and Guba (1985). Triangulation basically suggest to use different sources when gathering empirical data in order to be more certain about the accuracy of data,

find out the differences between different sources and therefore increase the reliability of a qualitative study. Regarding triangulation, in the scope of thesis, different persons have been interviewed from the truck OEM side, in order to understand different perspectives thus reaching to as rich data as possible. Also, in order to gather reliable data for transport providers' perspective, three different transport providers have been contacted regarding their perceptions of value in maintenance. Having two different perspectives and interviewing different persons from the companies have given a wide and objective overview of maintenance and a rich data collection with many cost and value aspects to the authors.

Another approach to increase reliability of the research is *"systematic combining"*. Dubois and Gibbert (2010), states that systematic combining approach is basically formed of three dimensions which are methodology, empirical reality and theory. According to Dubois and Gibbert (2010), as long as these three dimensions are linked to each other and there is interplay between them, reliability of the research will increase and the reader will be more convinced about the findings. When writing this master thesis, interplay has been performed between theoretical framework, empirical data and methodology. As long as new information has been received in the empirical reality, theoretical framework and methodology sections have also been modified in order to reach to the perfect match. And the matching has been reached through iterations between the theory, the methodology and the empirical data. Thus, these three dimensions have been linked to each other as good as possible.

According to Lincoln and Gubba (1985), another important aspect to increase reliability in a qualitative research is *"credibility"*. Credibility is basically related to the time that has been spent on the research in order to have a persuasive understanding for the context of study. In the sense of credibility, this research has been carried on for five months and during this period of time nine interviews with the truck OEM and the dealer, three interviews with three different transport providers and two interviews with other industries have been had in total. In order to have a convincing understanding about the overall maintenance concept, railway and aircraft industries have also been contacted. Even though the time that is spent on this research is limited, a big amount of this time has been invested on gathering as reliable data as possible.

4. EMPIRICAL DATA

In this section, the empirical data that has been collected from interviews with the truck OEM, the transport providers and other industries are structured and presented in order to be analyzed in the following section.

4.1 The Truck OEM

One of the aims of the truck OEM is to become the world leader when it comes to maintainability, and therefore, they have to be significantly better than their competitors. So, when they set the targets for maintainability, they also take into consideration what their competitors consider in terms of maintenance.

The main objective of maintenance is to optimize the planned stops for customers and minimize the unplanned ones. This is done by understanding how the customers use their trucks, as for instance what kind of mission they have and what kind of roads they take etc. Then this is put together and the time for servicing is optimized. After that, when designing the components, optimizing the engine or the chassis towards the customers' applications are to be accomplished. This is because trucks are considered as tools and their application or usage in its context is really important to be optimized both as the truck company and the customer. Then also from an environmental perspective, legislations should be met.

There are two main objectives of maintenance

1. Uptime of the truck, which is very valuable since a break down can cause big losses for the customer: the profit is very competitive and therefore it is very small and the cost for repair cannot be handled. By using service contract the customers can minimize the risk.
2. Competitiveness is also another objective, as in many cases the service contract is a criterion for customers to make choice between different brands and therefore the truck OEMs want to be competitive with their service contract.

The truck OEM performs two types of maintenance: Preventive maintenance and Corrective maintenance. Preventive maintenance the maintenance that should be done based on schedules and can be predictable; however, there are also some non-predictable operations, as wear and tear for instance, that could be estimated only. In addition to that, corrective maintenance mainly deals with repair. There are things that could break like water pump for example and that are also difficult to predict; and thus, there is no preventive maintenance for all components. For the preventive and corrective maintenance, preventive is the maintenance that is pre-planned and scheduled in order to have no stop in every certain period of time; but, corrective maintenance is always bad, as there could be a breakdown in road and the truck has to be brought to the workshop.

The truck OEM offers service contracts in order to increase efficiency and effectiveness of maintenance operations for their customers. These contracts are categorized based on the services that they cover and provide to the customers. There are three types of service contracts: Preventive maintenance contract, Preventive maintenance and Corrective maintenance on the driveline, and Preventive maintenance and Corrective maintenance on the whole Truck. Table 3 represents the three different contracts.

Table 3: Types of contracts and the services that is included

	Type of Contacts		
Services	**Preventive Contract**	**Preventive and Corrective on the Driveline Contract**	**Full Service Contract**
Control of all truck functions			
Lubrication of the chassis and the cabs			
Exchange of oil filters			
Compliance of the truck			
Repair of drivelines (engine, gearbox, etc.)			
Road side assistance			
Additional parts provided by the dealer (depends on both customer and dealer)			
Customization of own truck			

Sometimes customers have their own workshops, and therefore they do the basic services themselves and might not sign any service contract with the truck OEM. One of the reasons why some customers have their own workshop is that they do not own the same brand of trucks, and having an own workshop can be beneficial so it becomes possible to handle all the brands for everything that is not warranty related for instance. Another reason is that they have all the equipment needed for performing maintenance in their own workshops and visiting all the dealers will only take a lot of time.

However, those who chose to sign the contract are the owners or the operators that do not have workshops or mechanics and who want trouble-free ownership. However, the level of contract depends on how uptime critical the customers' organization is and how much advanced their businesses and processes are. Also, the market as such can be a driver. For instance, in Europe people are more contracts driven compared to the US. Anyhow, some customers are convinced to shut down their own workshops in order to focus on their core business, and have therefore opted for the service contracts. For the maintenance service provided by the service contract, the dealer takes care of the planning of the truck and when it should come in to workshop for the service.

Accordingly, the service contract covers some maintenance activities and some repair, depending on the type of the contract. It is also based on a monthly fee that the customers pay to the truck OEM. In other words, the service is paid by the truck providers to the truck OEM on a monthly base, and it covers the maintenance and some repair of the trucks. The truck OEM then sells the truck and the parts to the market company. The market company re-sells them to the dealer; who on his turn sells them along with the service to the customer. Figure 10 represents the cash flow of the chain between the actors.

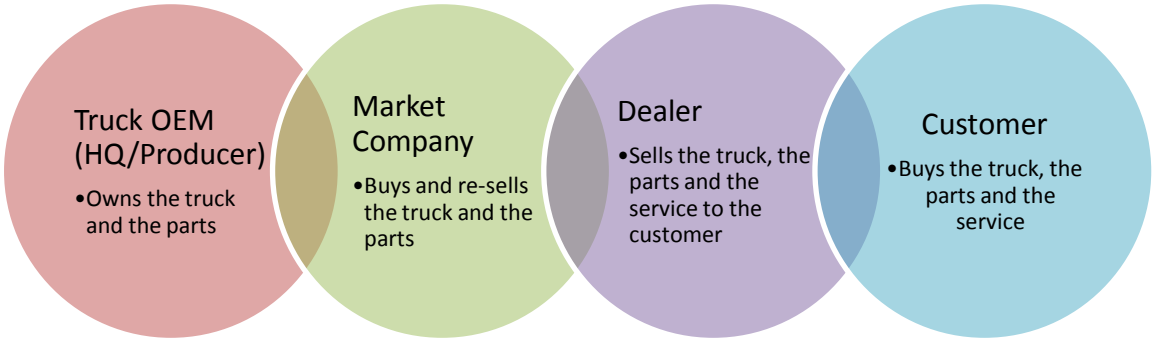

Figure 10: Cash flow between the actors in the chain

The truck OEM sells the parts to the market company and then makes a margin out of the parts, the parts then are bought by the dealers and they are the ones who provide service, finally the customer requires the maintenance service.

4.1.1 Costs from the Truck OEM's Perspective

When considering the cost structure, the truck OEM or their dealers provide service contracts to customers. These contracts however might not meet the expectation of customers, and then the risk the OEM takes is considered cost. However, it depends on the business model, if the service contract is offered by the OEMs headquarter then that cost is there, otherwise if it is on the dealer level, then the OEM takes the risk and the cost will depend on whether the OEM owns the dealer or not. Another cost is warranty, and the OEM has an extended warranty and which is something like insurance. In addition to that, training technicians to do a new maintenance service is also a cost that should be taken into consideration before introducing a new maintenance service.

The lifetime of a long haul truck is not the same as a city distribution trucks. The truck OEM considers around 30 different features that customers demand for the trucks and approximately 5 of them are related to VLP (Vehicle Lifetime Productivity). In VLP model, the impact is calculated both on the revenue and the cost from customers' perspectives in order to see the total cost of ownership for customers. In order to be able to analyze the profit margin, it is crucial to look at the both sides, i.e. the cost and the revenues.

The maintenance operations that includes engine, for instance changing the filter in the engine, are the most costly ones for the truck OEM. When the cost is considered, only the aspects are taken into account. However, some non- aspects, i.e. time, are converted into aspects. For instance, if the truck is taken out of operation for an amount of time for maintenance operations, the exact amount of time is also calculated and the customers are compensated for their non-operated time. Maintenance costs include the labor cost, part costs, i.e. oil, filter and the time. As the transaction flows through the chain, dealers, sellers and some other actors have different kinds of costs and different amounts of profit margins.

The VLP model consists of around 80 different inputs that are taken into the calculation and the cost for customers is calculated based on this model. When the long haul trucks are taken into consideration, for instance, one truck operates for more than 150.000 km per year and this brings a high cost to the customers since the operation includes the cost of driver, the cost

of fuel consumption and specifically when the trucks operate between different countries, long hauls also increase the overall cost. The biggest cost elements for long run operations in Europe are determined roughly 30% for fuel cost and more than 30% for driver cost. On the revenue side of VLP model, the freight rate of the customer is multiplied by the number of transport work and the tons per kilometer (ton/km) is found out. The maintenance operations are included in both sides of VLP model, both in the cost, i.e. the cost of parts and the time that is spent in the workshop, and the revenue sides, i.e. it impacts the transport work since it affects the uptime, if the customer has to go to the workshop 3 times instead of 2 times in a year, it decreases the uptime since he cannot operate his truck and loses revenue. So, according to the interviewee, each time the customer goes to the workshop, he loses his both hands.

Depending on the contract, the customer pays a monthly fee for the service provided by the truck OEM; however, if they decide not to sign a contract then they have to pay the repairs done in the workshop each time a problem occurs and which is costly for them. Sometime, the truck OEM earns money from the contracts, while some other times they do not earn. It actually depends on the repairs the customers have. Preventive cost can be estimated, as it is about what a truck needs per year but corrective cost cannot be estimated. Sometimes corrective maintenance might cost a lot when the truck OEM has to pay a lot, especially if the contract includes a promise to keep the truck running but that ended up having a lot of problems. The truck OEM then needs to give a replacement truck, as solving the problem in the workshop might take some days because they might lack some parts when the problem occurred. However, contracts do not cover corrective maintenance in case customers missed their preventive maintenance service but still it depends on the situations and the dealers.

35% to 40 % of total maintenance done in the service contract cost goes to preventive maintenance (including parts and labor). This creates monetary value from the customers' perspective. From the truck OEM perspective, labor cost is mainly the biggest part in the preventive maintenance, while spare parts take the biggest part of wear and tear. Approximately 20% is labor cost for preventive maintenance; however, it also differs from North to South Europe if Europe is considered for instance.

The cost of the contract is divided into monthly fees over the whole contract period; so it is possible that during the 1st period of time, the customer pays more than the workshop visit actually covers, but with time the repairs' cost will exceed his monthly fees as shown in figure 11 (note that this graph is a roughly representation of the costs and the values do not represent the actual cost nor the actual time).

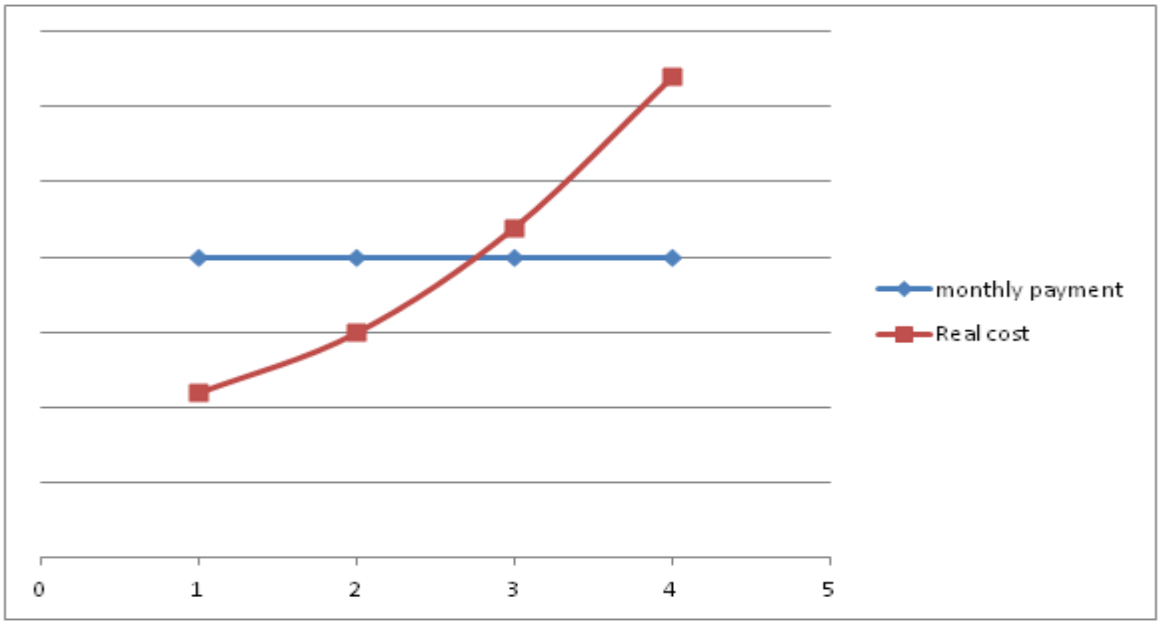

Figure 11: service contract cost vs. the real cost

One of the advantages of the service contract is that it is based on a monthly fee that is spread over the whole contract period. Another advantage is that it is some kind of insurance. So as stated above, when a customer has a part that breaks down by the end period of the contract and that is really hard to repair (gearbox for instance, that has high repair cost); then, if the truck OEM has not put the money on the early period of the service contract, they will not have money to repair the part at the end period of the contract. That is the reason why the truck OEM spreads the cost of contract along the contract time. Therefore, it is important to have saved money from the early period of the contract that will then cover the end period of it. Then the truck OEM makes provision, and the dealer performs the maintenance for a certain period of time with a fixed price but the cost could be higher. However, the truck OEM earns on some, and the portfolio they are maintaining should be as correct as possible even though it is not very easy to predict, as each customer will not have the same expenses. When the portfolio is done, it is not known what will break, and therefore for instance if only 10% of the gearboxes will fail, 90% of the customers will not have this problem. However, the customers want to minimize the risk so they buy this service, because if the engine or the gearbox fails, the cost could reach 200.000 (for instance) and that could be equal the ROI of the company. The table 4 below shows how the cost of the maintenance is divided between parts and labor.

Table 4: The maintenance cost elements in different regions

Generally	Nordic countries	Middle East and Africa
60% parts	50% parts	70% parts
40% labor	50% labor	30% labor

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4.1.2 "Benefits and Value" from the Truck OEM's Perspective

The truck OEM offers service schedule for their customers in order to follow up their trucks. However, some customers think it is not important to follow this schedule, which results in breakdowns and downtime. In fact, no customer is forced to follow the schedule of the maintenance plan, unless they want to the warranty. In other words, the customers can go to whoever workshop they want in order to perform maintenance, but they still have to follow the truck OEM's rules. The truck OEM also has checklist with a number of check points that should be recorded to be sure that the trucks are safe. The truck OEM then has to prove that they are the best service provider and business partners rather than forcing the customers to follow the plan.

When it comes to customers' needs, a lot of surveys are made: one is the productivity survey and is a qualitative survey from which few numbers of customers answers many questions. As an example 38 customers in Europe were asked some questions, including those who are working with construction and are mostly driving typical trucks. One of the questions they answered was related to the productivity and which was: "To increase the amount of good transported, rate the importance item of the following items (given several items). What is the most important item with an impact on the customer's productivity?"; the answer was fault frequencies which means faults in the vehicle that leads to unplanned corrective maintenance, which also implies a visit to the workshop and therefore a loss in revenues. However, in the automotive industry, for daily commodities as supermarket chains, customers have contracts related to on time deliveries. If they do not deliver on time, they will end up owing money and giving fines and might even lose the contracts. However, when checking the cost side, the most important costs are fuel consumption and cost of maintenance.

When it comes to the profit margin in the transport industry generated for the truck OEM's customers, based on interviews with persons within the truck OEM, it is considered to be very low. Transport is then an uncomplicated business and the transport buyers buy on price, so if the service is cheap they will buy it and therefore might even change the supplier if they find a cheaper one. In different countries in EU different, the profit margin is on average of 3% of total share revenue; which is considered to be very low. However, the transport business is of big spread; if customers manage to nish themselves in a specific kind of transport, the profitability might become high. There is a big variance from different customers, in the US for instance some transporters' profit margin reached 60% while some of transporters in Sweden have been running loss for several years. Then, when discussing low profit margin for transporters, the yearly revenues for non-haul transporters in EU is estimated to be between 150 to 200 thousands Euros per truck, and if a truck is running 150 thousand km with 185 thousands Euros revenues with profit margin 3.1% as share revenue, then that trucks makes a profit 5735 Euros per year. This is then considered to be very low profit for the customers. If taking as an example one unplanned stop for leaking water pump, that could cost 3000 Euros and which represents half that year's profit. Therefore it is extremely sensitive to perform corrective operations generated from unplanned stops.

As explained above about the preventive maintenance and the corrective maintenance, interrupting the transport makes customers lose profit (half of it as stated in the previous example). Also, even less sensitive problems like something working less good and have to be fixed in two weeks for instance is also seen bad as it requires time. But if it something that can wait then it could be something that only affects the customer's cost and not affecting their time then. Corrective maintenance is then what should be avoided and that is why the Truck OEM wants to move its customers from corrective to preventive maintenance as being

a matter of risk management in order to avoid the corrective operations. Customers have to come in and change some parts because that specific part will break after running a certain number of kilometers. Some customers are fine with that but some feel that they have low margin and then take a chance and hope the truck will not break, maybe 8/10 customers are lucky but then the other 2 end up paying that 3000 Euros generated from the breakdown that was estimated.

To define value from what the truck OEM's customers perceive based on interviews with persons within the truck OEM again, it is considered as the price of the freight trade that is offered, which represents then the revenue. However, if considering the non-monetary aspects of value, customers perceive qualitative indicators also that are of extreme value as delivery precision (deliver on time), also environmental concern especially in the EU that is also of big value and delivery frequencies. So, if delivery precision is considered very important, the truck not breaking down is also of big importance. Finally, there are productivity issues as the amount of transport work coming from vehicle and which is considered as big value.

According to another interviewee within the truck OEM, when it comes to value, it is perceived differently from one customer to another; however, the customers mostly base it on uptime. Whatever the truck OEM can do to support the customers' uptime will always be of great value. However, the improvement that any truck OEM is going after is to optimize the service maintenance towards the customers' real operations so that the uptime can be maximized; and the time spent in the workshop can be optimized. The workshop process can be efficient which all begins with diagnoses in an optimized way; therefore, there should be the right information to the right users in order not to generate frustration.

In balancing the benefits and cost, the truck OEM considers vehicle and technology change over time; along with knowledge including the checkpoints change for instance. In other words, if after years, the truck OEM has received no report of anything specific about a check point form the checklist performed during maintenance, then that check could be reduced to once in 2 years or even removed from the checklist. But the question is how to do that in the future? The more the preventive maintenance includes, the less check-points securing the uptime and that is the challenge in the truck industry as wear and tear and repairs are big parts of the cost.

Now considering the value for the truck OEM generated from performing maintenance using service contract to their customers, is to achieve uptime and be a backup for their customers, also to maintain their relationship with the customers and support their needs. This truck OEM might not be the cheapest but maybe it is the highest in value. When asked about the benefits generated to the truck OEM, the aftermarket is quite profitable. With contracts there is also loyalty as the truck OEM engenders good relationship with customers.

When it comes to the revenue streams, then it is about selling the truck and the whole chain is included. When it comes to maintenance, it starts from the dealers who request parts and the truck OEM only earns on parts while the labor stays at the dealer. To have more suppliers the truck OEM only owns the trucks (chassis and cabs), they do not have the other tiers (parts of the trucks), and so the customer goes somewhere else with tiers. In other words, the customer can have around 3 to 4 interfaces as for bodybuilder etc., and that is where the complexity occurs.

4.1.3 Cost of Poor Maintenance

Types of poor maintenance could include production fault, as electrical fault, that occurs is when water gets into the electrical lines and get small shortcuts, which is almost impossible to fault trace. Also it might be that someone made a mistake and got scratches on cables and then got water leak. *Repeat repairs* is one thing the truck OEM tries to focus on, and that is about fault tracing as the workers in the workshop don't know what is wrong, and don't know what to replace but instead just try replacing different parts randomly. That is considered as a cost that the truck OEM pays. However, it differs from one workshop to another; some have no repeat repair because they are good at diagnostics while others are very bad at it, so it is a matter of skills.

Poor Maintenance cost can be defined as if maintenance that is supposed to be done is not done properly, and whether the mechanics or technicians perform maintenance the way they need to do. In addition to that, from the transport providers' and buyers' side, poor maintenance is every time the customers have to come back to the workshop with the same problem. Poor maintenance however, is not about quality but from customers perspective they can consider poor quality as poor maintenance. Compensation of poor maintenance to customers and that many dealers do is by providing a replacement truck unless it is a bodybuilder and which is not that common. But at the end it depends on the service that the OEM offers. The truck OEM for instance has one service called promised uptime and they pay customers if they cannot reach 100% uptime, but it also differs from the service and maintenance contract and therefore reimbursement of extra cost depends on the contract and level of service and cost of the company will also differ then depending on risk associated with maintenance and service provided.

In order to identify the faults in the workshop, surveys are both done internally and externally. External surveys are done by independent research company. They have questions about the product, the workshop and the brand in general. For internal surveys, they are done by the OEM and are specific for dealers because it is important for the OEM to understand what happened wrong or want to improve and where they stand. Main reasons of poor maintenances are first of all to find faults from the first time the maintenance service is applied and also the service and repair. A way to improve is by reviewing the workshop process and understanding what and where it went wrong; also, there is improvement of diagnostic both in vehicle and workshop tools to optimize and minimize downtime for customers. There is high expectation of OEMs to move towards what train and flight industries had in years and which is to be able to predict.

According to another interviewee, poor maintenance can be as form of breaking the engine if the engine oil is not replaced in right time or if not the right oil is used for instance. This will lead to breakdowns and destroying the truck. Another example is that a customer might have a problem occurring with his truck that he believes he is not responsible of, so he goes to the dealer that provided him with the maintenance, this dealer will check if the problem occurred because of the parts or because of the labor. If it was caused by the labor then it is the dealer's fault but if the problem comes from the parts then it is the truck OEMs fault. Compensations for customers then occur in either ways; and it does not differ much if the customer has a service contract or not, however if the customer is outside of warranty then it is his problem. In addition to that, diagnoses can also be an example of poor maintenance; therefore well skilled technicians are needed. Automation can be a good idea assuming that a robot does the right thing and then it can also monitor things humans cannot, as rotating the wheels under pressure for instance.

4.1.4 Future Expectations

When only electric vehicles are taken into consideration for the future needs, it can be said that there will be no need to change filter or oil since engines will not consist filter and oil anymore. Therefore, it could be expected that the maintenance costs will decrease. The challenge about batteries in electric vehicles is that their life time might not last as long as the lifetimes of trucks and since they are extremely expensive, in some cases even more expensive than the truck itself, changing the engine is not considered cost efficient.

Swedish Government has set a target that by 2045, Sweden has to be a totally CO2 neutral country and since freight transportation causes a high amount of CO2 emission, usage of alternative propulsion systems is crucial in order to achieve this target. And in this sense, the government should take actions and determine the direction and alternative propulsion systems to be used in order to reach the goals.

With an electric truck the customers might expect to go to one place to get their trucks maintained and would want some kind of battery management service so they can have the same kind of services with diesel engine in the new driveline. And then after all, regardless to the technology all customers will be caring about maximizing the uptime. Besides, too fancy electrical drivelines cannot be developed if they take a lot of payload because for most trucks the money is generated from the load they can carry and if they will be heavy then it will not be allowed to carry as much load.

The maintenance for electric vehicle would look like the one for diesel, but a lot of signals should be sent from the trucks in order to keep track of the health of the systems. And therefore making calculations based on that algorithm for certain components. In addition to that, there should be an increase in the knowledge gap mainly and having good dialogue with the customers.

From another perspective, the maintenance for electric trucks will look different from how it looks today. There will be no oil and filter change, but there will still be a need for gearboxes and the rest of the vehicle, the wheels suspension, the service, there might not be a need for oil drains and that is an area where the entire value change. Probably medium trucks could be fully electric, but most likely they will be hybrid. For long haul trucks fully electrification will not happen unless there are electric roads and diesel will remain as the major propulsion systems at least for 20 years. However, electrified roads might not take place as EU because it is such an investment. Therefore, the diesel will be the main stream with a probability that there will be variance about different fuels on that, depending on what region has access to.

4.1.5 Influence from the Other Industries

When asked about how influenced the truck industry is by the other industries, as railway and aircraft, the truck industry is already having some functions that were inspired from the other industries as for instance in aircraft, they have one or two back-ups and that the truck industry is also implementing. The truck industry has some similar functions to the aircraft industry like for instance if the signals speed sensor is lost then it re-connects to ABS sensor so the truck can continue operating. It is expected that truck industry will have more functions like this in the future; however, it is mainly connected to the safety of the driver as in the aircraft industry, they cannot afford any stop or breakdown while operating, so duplications exist in trucks as long as it is connected to the safety. Being equal to the aircraft maintenance will not come at any time as the truck industry has to balance the benefits and the costs as long as the truck stops do not affect human lives as plane stops might. Also, sensors can break meaning

cheap sensors are not a solution. In addition to that, there are no legal requirements hard enough to prevent stand stills.

4.1.6 Time Study at the Truck OEM

A study has been done five years ago in different workshops and which were about two main different time studies:

- Repair history analysis
- Value stream mapping

Starting with a definition of uptime from the customers' perspective:

$$\text{Uptime} = \frac{(\text{the time they want to use the vehicle} - \text{the time they want to use the vehicle but cannot})}{\text{the time they want to use the vehicle}}$$

In order to perform these time studies, the truck has been followed through three different stages (figure 12).

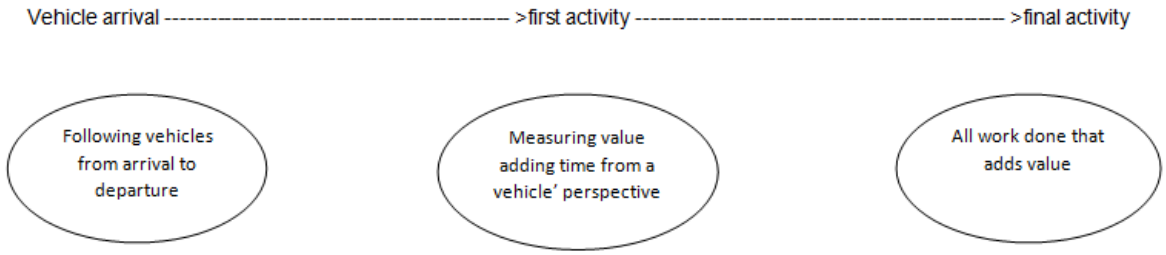

Figure 12: Different stages the trucks go through in the time studies

The studies then has been measured and 5 different areas has been studied: time it takes the truck from arrival to 1st activity, time it takes from 1st activity to final activity, waste time, necessary waste time and value adding time as table 5 shows.

Table 5: Five main areas of the study in three different countries

	Time to 1st activity	Time from 1st to final act.	Waste time	Necessary waste time	Value adding time
USA	1 day	Median 2 days	47%	16%	37%
UK	0.1 day	0.2 days	45%	3%	52%
SE	N/A	0.3 days	38%	11%	51%

When asked about what actions could be taken to reduce waste, rescheduling the tools' position was the first thing that was brought up. Actually, taking the tools and leaving them back creates the most waste, so a recommendation was given and that is positioning the tools closer to the repair bay. Another waste stated is movement, and that stands for the movements the technicians do in the workshop and which concerns mainly the layout of the workshop. Therefore, not many actions can be taken to reduce the waste in this case. Finally, trying to diagnose the break down is also part of the waste to which unfortunately not many actions could be taken, unless the technicians could know what to fix in the truck in advance. The biggest wastes could be categorized to 5 main groupings as table 6 shows.

Table 6: Table showing biggest wastes based on their percentage

Waste	Percentage
Tools	10.2%
Diagnose	8.0%
Movement	6.9%
Administration	5.5%
Parts' counter	4.5%

However, the percentage of waste differs from country to country based on the study, and if taking US and Sweden as examples, in the US the trucks used are actually garbage trucks, which implies that the workshops are bigger and therefore there are many technicians that work there, meaning the trust is not high, also the technicians have to walk a lot from one spot to another. There are then many factors that affect the value adding time.

4.1.6 Dealer of the Truck OEM

According to the manager in the dealer, most of the trucks are running in the building and construction segment 32%, almost 20% is long haul, 30% forest, and also local distribution, heavy transport, agriculture, and recently, recycling segment has been growing. The manager states that Volvo and Scania are the most preferred brands in Scandinavia, and the reason behind of this is that they have a big workshop network.

- **Costs from the Dealer's Perspective**

The maintenance is too expensive for the customers. In the future, the oil in the engine should be used for the double life-time so it will be cheaper for the customer and also it is very good for the environment. The operations should take shorter time, or should be performed less frequent. The cost elements of maintenance are spare parts and labor cost of the mechanics. And the manager considers that 50% is spare part and 50% is labor cost. The cost of equipment is not a significant cost comparing to spare parts and labor cost.

They keep the track of their customers' vehicles and when the trucks reach to a certain level of mileage; they get in touch with the customers to book an appointment for maintenance. However, it is not done automatically yet, so they have to make a list of their customer and follow them, therefore it takes a lot of effort. Pre-maintenance (preventive) is more cost efficient because customers stay in the workshop for a shorter time. If preventive maintenance could be applied for all the trucks, then the company wouldn't need 28 technicians. In this case, the number of technicians would decrease to 5-10.

- **"Benefit and Value" from the Dealer's Perspective**

The company does not want any trucks standing in the workshop, so the operation time should be as little as possible. According to the manager, if they can satisfy customers then they will increase their profit eventually. In the company, they have very short time for decision making; they can make decisions right away, so they can take action for the problems faster. On the other hand, the company has the same tools and equipment as the truck OEM's workshops and they work with the same standards.

The company always tries to sell what customers need. However when analyzing the customers based on what they need, they also take into consideration what the company needs in their portfolio. Company also has “availability/uptime” offers in the full service contract.

At the dealership, they will start implementing a new idea which is called “service on road”. This is for mainly pre-maintenance and small repairs. They plan to go out and visit their customers at their own site to make some small adjustments and repairs. When they go to the customers, they borrow customers’ own garage and perform maintenance there. Some of the customers have quite big garages; in this case they can even take some other customers’ trucks to one specific customer’s garage in one district. This service has to be planned. The purpose of this service is being close to the customers. And they also know that one of the biggest competitors does not have the same service approach. Mobility of the workshops will increase in the future. Because, as long as it is not a break down, the other operations in terms of maintenance are quite small and it is easier to make money. If the customer has a contract, he does not pay any extra for maintenance. But if he does not have a contract, he will pay additional expenses. Some customers do not prefer to buy contract because they are so focused and good at maintaining their own trucks, and also they don’t use very expensive and sophisticated trucks. However, if the customer is a big truck company without a workshop then it needs a contract, as it becomes more beneficial for them.

On the other hand, there is a difference between the skills of mechanics. Some of them have extremely good knowledge; while the other ones can perform only basic operations. The company still tries to increase their knowledge; however, technicians have different interests in terms of their skills. For instance, some technicians like to work with electronics, while the others prefer working with tools. Mechanics get a lot of training and it costs a lot to the company. Company does not have any difficulty about losing their mechanics. The manager says “they are a good team and no one wants to quit”. Even though, the mechanics are trained based on the standards of particular truck OEM, they can still perform maintenance for other brands. Since, the basic working principle of a truck is almost the same for different brands; the company does not perform advanced maintenance operations for other brands, advanced operations are performed only for the specific truck OEM. The future technologies will be more advanced, so are the maintenance operations. But the managers do not see this as a problem in their workshop. The biggest turnover of the company comes from spare parts and workshops.

When they have a truck on full service contract, they have the full focus on the customer. The customers have a schedule and they know when they will visit the workshop, so they can plan themselves and the company calls the customers to book the appointment. At the same time, they order the spare parts for the appointment and also plan which mechanics will take action for the specific appointment, and customers know how long they will spend in the workshop. The longest time is one day and shortest time is 2,5 hours. If it takes more than the planned hours, in the full service contract they compensate the extra hours for the customers. However, it does not happen so often. The compensation could be another truck, or some credits for the next repair or money. The company never says no to the customer demands, therefore some problems can occur sometimes about the planning process.

One of their focuses is repairing right for the first time. And this is an issue for the company currently. Because the diagnosis system does not always give the right answer at the first time. Therefore, it is very important to have mechanics with good knowledge. Because they don’t only focus on the computers, they also use their own knowledge and experiences.

The customers mostly care about the time and the money that they spend in the workshop. They tend to spend as minimum money and time as possible in the workshop. Since the customer cannot make any profit in his business during the time that he spends in the workshop, it is crucial to keep the time as short as possible. And also repairing the trucks right at the first time is another important performance indicator from the customers' perspective. Therefore, the company has to order the spare parts in advance so that everything will be ready when the customer arrives and also the diagnosis should be made correct at the first time.

- **Future Expectations**

In the future, managers see that electricity will be quite common. However, the trucks should not be 100% electrical. Hybrid trucks should be used, diesel engine for the long distances and electric vehicles in the cities. And main value out of this technology for the customers would be the low fuel consumption. And also, since the regulations are quite strict nowadays, transportation companies would also care about environmental concerns. Maintenance is not considered hard or dangerous for electric vehicles. It has been stated that "it is all about the education". And also, the manager assumes that, it will be less break downs and maintenance requirements with this new technology. Using electric vehicles might affect their business, because maintenance requirements will be reduced. However, the managers stated that in this case, they should consider trying to find and sell some other products and services, because electric engines will be there in the future for sure and there is no way to avoid from it, so they should find their own way to survive.

On the other hand, the manager stated one problem about maintenance management that should be improved in the future. When the customer has a problem with the truck, he comes to the workshop and they make the diagnosis for the truck and book it in 2 days later. So they can order the spare parts. Because it is not possible to keep all the spare parts for all different models in their stocks. In this sense, they think that this process should be improved with a more effective maintenance management system and the customer should be more satisfied in the future. However, this is extremely difficult to implement. In the future, the trucks should be connected to the workshops, and as soon as they go into the yard, the faults should be diagnosed, regardless of which service agreement the customer has and they can read all the faults, when trucks are still on the road. So they have the right spare parts and mechanics, and they know when the truck is coming to the workshop. If there is another button in the trucks, they can help them on the roads and give the drivers advice.

Another future expectation comes along with operation times. The most time consuming operation in the workshop is when something is broken with the engine. This is also the most expensive operation; however it does not happen very often. The manager says it is also possible to reduce the time for these particular operations. In the future, the manager foresees that some parts that are being replaced currently could be repaired instead. So that the required time will be decreased since changing the parts take more time than repairing them now. The manager states that it would have been good if they could perform more repairing operations instead of replacing.

4.2 Transport Providers

In transport provider A, they are doing the purchasing of trucks in European scale. The manager that has been interviewed in transport provider A is responsible of the trucks that the company owns in Sweden and also he is the responsible of purchasing trucks for other

divisions in Europe however, not the responsible of subcontractors. In Sweden they own 550 trucks in their fleet.

They describe maintenance in two different ways: preventive maintenance and damages. Preventive maintenance is done by schedule and also according to the manuals that is given by the manufacturers. Today, trucks have less service intervals than they used to have in the past. In terms of preventive maintenance, they do maintenance once in six months or once a year while they used to do maintenance twice a month in the past. Preventive maintenance is considered always the most cost efficient type of maintenance. However, it also can be that they need maintenance in between due to the damages and this cannot be planned in advance. Damages are observed almost every day and they have to stop by the workshops very often. Even though the damage is not on the truck itself (maybe it is just on the trailer), they still have to maintain the whole vehicle and take it to the workshop.

From transport provider B's perspective, they both own and lease trucks. The maintenance for both owned and leased trucks is done in the same way and that is mainly outsourced. In other words, this transport provider does not own any workshop; but rather uses service contracts for the trucks they own, and gives the responsibility to the truck owner for the ones leased. When this transporter was asked about what workshop they go to, either the truck OEM's workshop or a private workshop, they stated that they have service contracts with the truck OEM to maintain and repair their vehicles; however, for some of the work that is not related to chassis but rather body builder for instance, then the providers use other workshops that are a better fit to repair and maintain the bodybuilders. This then includes both preventive and corrective maintenance.

Transport provider C transports passengers and vehicles. When they transport new cars, they have to put the driver in the cars. For instance when someone buys a car, the factory will ship the car from one port to another and the company moves the car in ports. They also have trailers and when the trailer is coming down to the port, it will be dropped at some point and carried to the port by technicians in the company. In the ports, they do not use trucks. They use tug masters instead which is a smaller version of trucks and basically have the same principle in terms of maintenance. They have approximately 4 million handlings in total. The production cost includes labor, port taxes and the cost of machines. Labor cost is the highest cost aspect in production cost.

When it comes to working with tug masters, 3 different business models are being used in transport provider C. They can either purchase the vehicles, or they could lease vehicles and use external or internal services. If a company like transport provider C, or any company that is on the stock market, has to go and make an investment, they have to make a return on the capital. The interest rate is quite high, because the owners expect to have return in their money. The manager states that, "if you plan to invest on something, you would expect to get at least 5% of return. However, the interest rate for companies like transport provider C is between 7-10%. Every time you put some capital in, you want it back as soon and much as possible". The rules in the company are very strict; they have to return the money fast and with high interest rates. And it costs a lot of money. The other alternative is going out and leasing the vehicles. And then they could use either external or internal services afterwards. Due to the high interest rates, the manager highlights that "when the company leases the vehicles, they actually spend less and in a longer period of time.

4.2.1 Costs from Transport Providers' Perspective

The cost elements of maintenance are mainly labor costs and spare parts. Biggest service cost includes oil and filter and labor cost and some certain type of spare parts. As a customer in the workshop, they care most about the time and cost at the end of the day. They want to squeeze their fleet and maximize their utilization. When they stop on a service, it has to be quick; otherwise they will need to buy extra capacity which means they will have double cost. When they go to a workshop, if technicians say "they have lack of spare parts and you have to wait for three days", then it is a problem for transport provider A. Then the question is "who pays for the waiting time?" and in this case, depending on what agreements the customer has, they should finish the maintenance as fast as possible but if it will be a delay, they must replace the truck. But in the end the customer always pays for it one way or another and it costs.

When it comes to transport provider B, the cost is mainly related to the service contracts that is of a fixed monthly price, also some repair on the parts that break down. In addition to that cost, there is a commission cost but that is considered separately when considering the Total Cost of Ownership.

And from transport provider C's perspective, the total cost for vehicles includes repair/damages, tires, diesel consumption, driver cost and the cost of idle time. Regarding maintenance cost, the manager has stated that if they could reduce the idle time, the maintenance cost will decrease as well. One of the biggest aspects that affect the idle time is drivers' behaviors. And the manager believes that the importance of education becomes prominent.

The cost elements of maintenance are labor cost and spare parts cost and these two elements share the total cost of maintenance as almost 50%. The most expensive operations are actually dependent on the technicians. When they are efficient, the cost is relatively reasonable. However, sometimes when they don't work efficiently, the maintenance cost increases a lot.

4.2.2 "Benefit and Value" from Transport Providers' Perspective

In transport provider A, they don't have their own workshops, and they buy maintenance services from the market. They use authorized and non-authorized workshops. When you have such a big fleet, you will need support as much as possible and therefore they work with many different workshops. Depending on the location, sometimes it is not possible to find a authorized workshops. In that case, they use non-authorized workshops. On the other hand, cost is another aspect when making a choice between authorized and non-authorized workshops. If they do the planned maintenance which is once a year, they prefer the authorized workshops, because authorized workshops can perform some specific operations, i.e. software update, etc. But if it is a minor repair for damages, i.e. bumpers, lights, etc., they prefer non-authorized workshops because non-authorized workshops are relatively cheaper. As long as they have the warranty, they go to authorized workshop, but when the truck is old and the warranty does not cover repairs anymore, then they go to non-authorized workshops. The reason to outsource maintenance is the cost. The manager states that "If you want to keep workshops, you need a big volume and regular investments in education and tools etc. and it is not your own business." They used to own workshops but they don't see any benefit out of this business, so today they don't own any workshops. They have to find a way to do it better and cheaper than the market in order to own workshops however, maintenance is not their core business. And the manager states that outsourcing maintenance is the best option.

The manager also highlights that "the more you squeeze the time for regular maintenance, the more you will increase the utilization of your trucks and the less you will invest on capital. You always need to have a balance between cost and benefits". Transport provider A is one of the biggest fleet owners so the manager states that they have to be good at balancing the cost and benefits on their fleet.

For the other transport provider outsourcing the maintenance was of benefit to the company. If the transporter owned the workshops then they would have to have them spread all over the places where they perform and that would be very costly for them. So the main reason of outsourcing is of economic benefit. What was valuable for them in this sense is that they want the trucks to run more effectively over the year, prevent breakdowns and also having fast turnarounds in the workshop so the downtime is lowest as possible. The transporter stated that today's situation is working very well, as the maintenance is mainly done during the off hours as weekends or night time when there is not much traffic. The production is done during day time and the service and repair is done during night time and then back again to the production in order not to have spare capacity.

And the manager from transport provider C talks about the benefits of leasing the vehicles as "When you buy the vehicles, you have the full ownership and you can do anything you wish to do, but when you lease the vehicles, you just operate it and someone else owns it. And since you are not a truck manufacturer and this is not your core business, you actually would want someone else to take all the risks about ownership." Therefore, leasing the vehicles instead of owning them and also buying maintenance services externally is more beneficial for the company. Renting the vehicles is cheaper than buying them and also the company prefers someone else to take the responsibility of the vehicles, in this sense, leasing is the best option for this transport provider. And also, since it is the core business of truck manufacturers, they will have better knowledge, experience and high quality spare parts in terms of maintenance. They use leasing and in that sense, they lease the trucks along with their maintenance services, but also in order to mitigate the risk of being out of vehicles, they still own some certain number of vehicles and they perform the maintenance operations for those vehicles. Their main focus is higher productivity in the company, and they have seen that when they leased the vehicles and bought maintenance services, they can focus on their core business and this increases their productivity. The manager states that outsourcing the maintenance completely to a good-skilled company would be a very nice idea to increase their productivity, and personally he would go for a business model where the supplier takes care of everything and he can only put some KPI's to measure if they are doing it right, because it gives a higher productivity and better focus on our core business and outsourcing completely has also become more common recently.

Another benefit of buying services is that they know what they have to pay at the beginning for the services, so they won't face any unpleasant surprise at the end of the day in terms of cost. And also, when they do the maintenance, they have to pay for the labor cost as well, and the labor cost can change based on the country that you operate. So, in some cases, labor cost could be very high.

4.2.3 Cost of Poor Maintenance

The manager in transport provider A states that they have poor maintenance experiences. The manager points out that poor maintenance mainly occur due to poor quality of the vehicles. As an example, he mentions about 30 trucks that they have bought from one of the big truck suppliers. However, even though the trucks are technologically advanced, he states that they

are not ready to be used. For instances, engines cannot tolerate the weather conditions when it is -20 degrees. So the supplier should have put the trucks on winter test before they sent them out.

On the other hand, sometimes the technicians in the workshops are not highly skilled and they also cause poor maintenance. However, in this case, transport provider A sends the bill to the workshop and the workshop has to fix what has not been done correctly the first time. But, this problem still affects their timing and breaks the transportation chain. Since the cost of time waste is quite tricky to define, they tend to choose suppliers with high quality in order to avoid this problem from the beginning. And he states that the cost of poor maintenance is not significant in their organization however the cost of poor quality is considered as a big issue. In transport provider A, they are very strict about the quality of products, so they don't work with suppliers that cannot provide a certain level of quality.

In transport provider B's perspective, poor maintenance is not of a big problem as it does not affect their cost; and that if it might occur, the workshop is responsible of compensation. The transporter complains to the workshop and on return they receive trucks that can operate for them in the meantime. The transporter explained poor maintenance as being bad feedback about things that should have been handled but did not been treated on time, or not completing all the checkpoints by the workshop that is supposed to be done.

From transport provider C's perspective, the manager states that "The maintenance is either good or bad, nothing in between. If you have good maintenance, you don't actually feel it because everything works well, but if we have to spend time on maintenance then it is bad maintenance because it is not our core business and we are not supposed to spend time on it." According to the manager, poor maintenance means that the vehicle does not work properly. And he also states that they don't have poor maintenance. In any case of poor maintenance, they stop the contract with particular suppliers. Because, avoiding from poor maintenance is a part of the contract and if they fail, then there is no contract with the specific suppliers anymore. They don't have poor maintenance in their workshops either. Transport provider C is very strict about poor maintenance.

4.2.4 Future Expectations

Quality of the vehicles should be improved in the future. Development of the techniques goes so fast and many times when there is a new unit in the market, it is not actually completely ready to be used and when the vehicle is started being used, lots of technical problems occur. As an example, in transport provider A, they have long haul transportation between Stockholm and Lulea, and the transportation chain is strictly scheduled in order to avoid from congestion in loading bays on each location. When there is a technical problem due to quality issues in one truck, it actually affects the whole chain and causes a big congestion in loading bays. Normally, they put new and fresh trucks for this long haul traffic in order to avoid such problems. However, they still cannot avoid technical problems that are caused by poor quality. And even if the truck supplier replaces the truck, this problem still has a big effect on timing because they have to find a loading bay and unload it and reload it and also it could be the case that the truck carries temperature controlled goods. And also driving hours will increase due to such problems. Therefore, even if the supplier compensates the truck, it is still a big cost for the transport provider. And it affects their total cost of ownership. So, the manager states that quality must be improved in all aspects to avoid unplanned stops in the future.

The manager thinks that the autonomous driving is quite far away in the future. And also he believes that platooning will not be a success as long as it is not a long haul and regular traffic that goes from A to B each time. On the other hand, the first truck in convoy will consume more fuel than the rest of the convoy, and in their fleet they have trucks from different suppliers, so it is very hard to share the cost and benefits for the suppliers. If there is only one brand in their fleet and the trucks are exactly the same, then this might be acceptable. However, in transport provider A, they have 5 different subcontractors and they have different brands with different trucks, with different engines and with different weight due to the load capacity. So the manager states that this is a huge problem to solve with a lot of variables. When it comes to electric vehicles, he sees the biggest problem is how the power should be stored. For the long haul transportation, trucks will need a bigger battery than is needed in short haul transportation. And in this case, the weight of battery will decrease the loading capacity for each truck thus; it will affect their profit margin. In terms of maintenance of electric vehicles, it requires less maintenance than the trucks with diesel engines but the technique is more expensive. So, the influence on transport provider will be that they will have to pay more monthly for maintenance. On the other hand, about electrified road, the manager thinks that it will have a negative effect on transportation due to the weather conditions in winters.

From a perspective of transport provider B, the maintenance of fully electric vehicles would result in lower cost. Since they already have some electric vehicles they are in a good position to explain how the cost of the service is actually lower. 1200 small electric vehicles are owned by this transporter, and compared to cars with same size, the cost of maintaining the electric vehicle is half of the cost. However, there might be drawbacks as the price of the electric vehicle and the loading capacity as the electric engines are heavy.

The manager from transport provider C argues that the maintenance of electric engines should be the responsibility of vehicle manufacturers or the suppliers. The manager states that they wouldn’t want to invest on new tools and equipment in order to maintain electric engines, since this is not their core business.

The future expectations from the manufacturers could be repairing things faster, and also the maintenance should be visible. Customers should be able to see the workshop when technicians are performing maintenance and they should be able to have a dialogue with the technicians, so that the technicians will feel more proud and it will increase their performance.

4.3 Other Industries

In this section two different industries have been interviewed which are the aircraft and the railway industries, in order to have a better understand regarding maintenance and also to investigate inspirations regarding improvements for maintenance operations in truck industry.

4.3.1 Aircraft Industry

One of the industries that have been studied in order to have a better understanding about maintenance is aircraft industry. Aircraft is such a capital heavy property and it must be taken care of quickly and the safety should always be the priority. Since the majority of aircrafts should be running during the day time, the planned maintenance is performed during nights. When working with aircrafts, the time limit is quite strict, so everything has to be planned carefully. When it comes to managing maintenance, in the company, they have central planning department which monitors if the tasks have been done and also when the next task should be done. Maintenance programs are usually given by the manufacturers but they can

customize it a bit for regarding short time periods, not for long terms. Maintenance schedules are monitored and given out on the computer. After receiving the schedule, production planning is made by the manager. He plans which tools should be used and also who should work on specific tasks. Flight controls and engines are one of the most important things that should definitely be checked in aircraft maintenance.

- **Cost**

Economical departments squeeze them to reduce the expenses in the workshop. They try to prioritize customer requests. In some cases, depending on the customer demand, they give advices to the customers rather than taking the aircraft to the workshop. When the maintenance is planned, then it is easier to measure the value that has been generated out of specific costs.

Cost elements of aircraft maintenance mainly are labor cost and the cost of spare parts. The manager states that the labor cost is the most expensive cost element in their workshops. However, the spare parts are also very expensive comparing to the parts of trucks. Since all the spare parts should be manufactured and certificated to be used in an aircraft, it actually increases the cost. Tools and also the rent of hangar are the other cost elements. On the other hand, the most expensive operations include changing the engine. And it requires 2 days of working by averagely 4 technicians and it costs few million dollars at the end, including the cost of new engine and labor cost. However, it is not observed very often.

- **Poor Maintenance**

Poor maintenance can be experienced when the administration tends to reduce costs in workshops. It affects the quality of maintenance. However, it doesn't happen in Sweden. And also poor maintenance is not accepted in such an industry where the safety problems can create a disaster in society. Therefore, the manager states that they do not have poor maintenance.

- **Value**

The value from their customer's perspective is safety, the service quality and also prices. Since safety is always the priority in aircraft industry, some parts of aircrafts, such as engines, are duplicated in order to keep safety on a high level. On the other hand, from the company's perspective, the benefit is keeping the uptime as high as possible for their customers.

- **Future Technologies**

In the future, the regulations should be changed. There are some areas that could be performed in more efficient with the same safety level, however the current regulations are too strict and aircraft industry cannot be improved as it is required. Authorities should be more open-minded, wider in their perspectives and also up-to-date regarding new solutions.
In aircraft industry, electric engines have been tried for a while, however they are considered for smaller aircrafts, not for the big ones. And the manager states that, in the future, electric engines can only be used for small aircrafts. Because the big aircrafts require a big amount of energy, therefore the batteries should be quite heavy and this will give a negative effect on aerodynamic design of the aircrafts.

4.3.2 Railway Industry

When interviewing a former responsible for the maintenance optimization for trains in a maintenance provider for railway, it was stated that there is no big difference between the maintenance of trains and truck; however, the variables are different. There is difference in

the owner structure of the vehicle, the owner structure of the infra structure, there are few vehicles in the railway industry compared to the truck industry. In addition to that the consequence of unplanned stop on railway is high compared to trucks because if a train with malfunction coming from 1 station to another, half of the train traffic in the country will stop. In other words, the variables are quite differently dialed in but are roughly the same.

However, when performing maintenance normally the trains are taken to the workshop. In order to understand how the maintenance for the railway industry works and how the whole business is set up of many different actors, the railway network should be explained:
Up to 1999, SJ owned everything; all the trains and the trucks were owned by the government. However today the actors in the network are:

- Infrastructure in the total rails owned by Banverket
- Stations and most workshops or houses owned by Jernhusen
- Independent maintenance service providers such as Bombardier etc.
- Public transport authority (PTA) as Västtrafik.
- Operators as Sj, Norrtåg, etc. that operate on trucks and are free to bid on different traffics. For instance if Västtrafik would like a train to go from one destination to another, a bid is open and people come and bid on that tender and someone will win that.

After that, for instance, the problem could occur when it is a 3 years' operating contract. A train costs around 120M SEK, so leasing the train for 3 years is more beneficial. Most operators then have collaborated together and created a company called Transitio that owns a lot of trains so when someone wins a bid for a certain period of time they can lease them. Then as an operator that won the bid, goes out and does their own tender because they need maintenance and maintenance companies bid on the tender and one wins, then they also need somewhere to do maintenance and start to negotiate on where they can find a workshop to do the maintenance in and they are quite spread all over the place. Contracts are relatively short and in that service contacts and the maintenance providers are charged per KM and they bid on a price on KM. Then as a balance to that there is uptime target which is between 99.50% and 99.80%. However, the cost of moving from 99.50% and 99.80% is surprisingly big; so, from maintenance provider's perspective, getting a set of 30 trains that are between 5 and 15 years old and in which many things should be continuously done and revised, are not that cheap. The trains are taken every 2nd week usually for safety checks which is controlled as safety is the first priority and that should be higher in trains compared to in vehicles. A lot of safety checks and several things are very costly like doors for instance; there are any safety demands on doors because they should not open while the train is running in 250 km/hr so there is a need of lot of checks and over holding them. When the train when manufactured, it is certified so it is allowed to go on the railways and certified with the maintenance schedule that cannot be changes (unless there is an approval to do so from Transportstyrelsen) contrary to the truck industry.

The maintenance is also very different, individual and not defined, but roughly similar. So there could be separate contracts with many maintenance providers. And the main criteria to choose the providers are cost and uptime. The main difference between trains and trucks are that the main criteria of purchasing a truck are a good relationship with the workshop because when buying a truck it is known that the workshop can do a good service. It is not the only criteria but it is surprisingly a big one. However, for trains it is flexible, the trucks and service stations are there physically, but the provider can be changed within that workshop very easily

by changing the tag on the door and just switch the personnel and then there is not much to worry about in the geographical locations unless there is an availability problem.
It is not a high margin business but they do it from a strategic perspective as they want to do maintenance on the trains they manufactured and sold, that gives them reputation and competence to develop better trains in the forwards. There are also time tables in both industries in which there are deliveries to make at a specific slot and the consequence of missing that slot in trucks is less important than in train, because for the trains it will come up in the headlines of the newspaper.

The maintenance operations for trains are similar to the maintenance operations for trucks. The 1st thing that many firms do is inspection: visual and functional. There are three types of maintenance:

- Preventive/scheduled maintenance (PM)
- Corrective maintenance (CM) like for accidents or crushes
- Preventive corrective maintenance (PMCM)

Maintenance is done starting by condition based maintenance; for instance, if considering the break checks for disks, the process is based on checks and to see how thick is the break disk and decide if it can run another two weeks and then follow up and start predict when in time the stock balance and purchasing can be done. According to that, the material is utilized as much as possible because it is expensive to over repair, so there should be a balance between cost and uptime. There should be measurement, looking, check and doing as little repair as possible but good enough to meet the safety checks and reach the uptime target. Maintenance is mainly done during the off-peak hours.

- **Cost**

When having a contract to provide a 99.8% of uptime, the actors have to be aware of what they are doing. The document that defines uptime is very big, and as a maintenance provider, they sit with the other actors to define what has been met and what has not. It is kind of a blame game. For instance, if the train was not available, and the problem was then poor infrastructure then it is not the fault of the maintenance provider. This is mainly done because there are both bonuses and fines connected to the uptime target. If then as a maintenance provider, better than 99.8% uptime is reached, given that it is the target then they get bonus and if they do bellow that, they get fines. The bonus usually is not worth getting as it is way more expensive to get up from 99.8 to 99.85; so there should be a balance between the cost and the benefits of increasing the uptime target.

- **Poor Maintenance**

When it comes to poor maintenance, it occurs by either trying to fix something and end up creating another problem, or not fixing or not do maintenance at all. However, when it takes too long time, or too much is done then it is more of a waste of money more than anything else. Waste of time and money is not necessary poor maintenance. Poor maintenance is also considered as also poor business. It is better to take a bit longer time and having things done properly the first time rather than having to do it again. In addition to that, in order to increase the uptime, it is very expensive because there is a need to over repair certain things so there is a certainty that things will not fail. The more over repair, the more time is spent in the workshop and the more things are changed.

- **Value**

Value from customers' perspective is to make money and run trains. However, there are different targets and customers tend to want different things. Some want comfort and clean seats, and internet and power outlets should be working; some on the other hand do not care, as they know people will take those train connection anyway so it will be just costly. Quality of work and predictability are the two main drivers to keep a contract. The train should not stop at wrong time and wrong place; but, speed of doing maintenance (automation) is not so important as long as the scheduled time of maintenance is kept. As maintenance provider, it will be beneficial if the maintenance can be done faster; but, for the customer the train will be taken off service for a specific time anyway, so accuracy is more important than speed.

- **Future technologies**

When it comes to the maintenance of the train, it does not have a battery as an electrified car does; more precisely, it does contain one but not to that extent (as a car battery). So, there is a cost shift from maintaining a diesel combustion engine and gearbox and which is expensive. If considering an electric motor, that needs a little maintenance but then there is a battery which cost is today very expensive. It lasts for couples of year so there will be a cash flow issue. Therefore, if there is a vehicle that after 5years needs a battery replacement the value of the vehicle will be quite connected to the cost of replacing the battery and which means a huge onetime cost which is cash flow wise compared to today that is fluctuating and continuous spending . This means different finance implication.

When it comes to future technology improvements, from his opinion it is not understandable yet the complexity of the artificial intelligent and "personally I prefer real stupidity over artificial intelligence". But with new technology, the need of maintenance's can be decreased and less can be done.

5. ANALYSIS

In this section, the empirical data that has been collected from different actors will be analyzed based on the concepts that are provided in theoretical framework. The section is divided into three parts. The first part provides the analysis of value, benefits and cost elements from the perspective of the truck OEM, while the second part states the same analysis but from the perspective of the transport providers. The last part then compares the perspectives of each actor and highlights the differences of perceptions in terms of value. And finally, the last part of the analysis discusses about the consequences of these perspectives differences for the truck OEM.

5.1 Perspective of Truck OEM

Here, the perspective of truck OEM will be analyzed in terms of cost and poor maintenance, benefit and finally value based on the concepts given in theoretical framework.

5.1.1 Costs

According to Salonen and Deleryd (2011), maintenance cost can be divided into two as cost of conformance and cost of non-conformance. Cost of conformance stands for the costs that the organization cannot avoid from and has to pay in any case. And cost of non-conformance indicates the costs that do not add any value to the operations and can actually be avoided or reduced as much as possible.

Based on this distinction which has been provided by Salonen and Deleryd (2011), it has been analyzed the truck OEM has cost aspects that is not possible to avoid from but also aspects that can be reduced. First cost aspect is the cost of service contracts. If service contracts are offered by the truck OEM then this cost aspect cannot be avoided. However, if the truck OEM does not own the dealers, then the cost of service contracts belongs to the dealer, which means this cost aspect could be turned into non-conformance cost. Another cost aspect is warranty cost. Since warranty is offered by the truck OEM, this cost aspect will always be on the OEM's side. On the other hand, the cost of training the technicians is also an important aspect. Before introducing a new maintenance service or a new truck, the technicians should be trained and this training is provided by the truck OEM, in order to make sure that all technicians are trained by the same standards. Taking the importance of high quality education into consideration, this cost cannot be avoided. However, this could be relatively reduced. It should also be noted that if the reduction on the cost will affect the quality of the education, then this cost should be considered as cost of conformance and should not be reduced.

Among the operations regarding maintenance, the most expensive operations are considered the ones that include engine. Especially that if the engine needs to be changed, the cost is quite high for the truck OEM. Unfortunately, the cost of changing the engines cannot be completely avoided. However, improvements on the engines can increase the quality and also the lifespan of products. In other words, the experience of changing engines will be observed even less often. This aspect will still be cost of conformance; however, the total cost of changing engines could be decreased. Time is also another cost aspect for the truck OEM. If the maintenance operations cannot be performed within the specified time, then the OEM has to compensate the extra time to their customers. This cost is considered as cost of non-conformance and can definitely be avoided. Better scheduling and order planning for the spare parts could be helpful to avoid this cost aspect. Maintenance cost mainly includes the cost of faults, the labor costs and the cost of spare parts. The cost of faults and the cost of

spare parts could be reduced, however the labor cost is totally dependent on the country that the OEM operates, therefore the labor cost is considered as the cost of conformance.

On the other hand, the cost of preventive maintenance can be estimated per year and considered as cost of conformance, whereas the cost of corrective maintenance is not easy to estimate and it can vary from year to year and is considered as the cost of non-conformance. The truck OEM has to pay for the expenses that the contracts cover however, if the customers do not follow the preventive maintenance schedule, in the any case of an accident or repair, the OEM is not the responsible of repair cost and the cost of corrective maintenance turns out to be the cost of non-conformance.

In addition to these, from the dealer's perspective, the cost of maintenance has two main elements which are the cost of spare parts and the labor cost. As it has been analyzed above, the cost of spare parts could be reduced since a part of their cost is due to poor diagnosis, changing the parts earlier than they should be or even when trying to fix one part, the technicians end up breaking another part etc. On the other hand, the labor cost is an element that the company is not willing to reduce as they are more customers focused. On the other hand, as it has been discussed in the empirical data, shifting from corrective maintenance to preventive maintenance would decrease the number of technicians in the workshops thus, labor cost could be reduced. However, even though shifting 100% to preventive maintenance is the ideal situation, it does not seem possible. There will always be some amount of corrective maintenance, which means labor cost will always be cost of conformance for the company. The cost matrix including the cost aspects of poor maintenance for the truck OEM has been provided below on figure 13.

- **Cost of Poor Maintenance**

As it has been discussed by Salonen and Deleryd (2011) in theoretical framework, poor maintenance can be divided into two as poor preventive maintenance and non-accepted corrective maintenance. One type of poor maintenance can be observed when technicians in the workshop cannot actually diagnose what the problem is and they change different parts randomly. However, the problem is that this approach most probably leads them to send the truck back to the customer without solving the actual problem. And the customer comes back to the workshop again with the same break down in a very short time. This type of poor maintenance corresponds to non-accepted corrective maintenance. Since the truck OEM is responsible of this fault, the cost of taking customers to the workshop for the second time belongs to the OEM and it has been analyzed that this type of cost should be considered as cost of non-conformance and also should be avoided.

On the other hand, it could also be the case that the technicians miss some parts that should be replaced during the preventive maintenance and it also causes to have problems later on even if customers follow the maintenance schedule. This basically addresses to poor preventive maintenance. According to empirical data that has been gathered, in some cases, technicians might replace the spare parts before it is needed in order to avoid the risk of having a break down in the future and Salonen and Deleryd (2011) argues that this corresponds to unnecessary preventive maintenance. On the other hand, technicians might miss some checkpoints during preventive maintenance and send the truck back to the customer without controlling everything and the customer brings the truck to the workshop before his next appointment due to a break down which occurs from missing checkpoints. According to the literature, this addresses to poor preventive maintenance.

The truck OEM has set a target of 100% uptime for their customers, therefore if uptime decreases below 100%, they compensate it for their customers, mostly by giving a replacement truck. However, since the OEM is responsible of poor maintenance, the compensation also belongs to them and it has been analyzed that this can also be considered as cost of non-conformance for the OEM.

	Corrective Maintenance	Preventive Maintenance
Cost of Conformance	Cost of changing engines, Cost of changing oil and filters, Labor costs	Cost of service contracts, Warranty cost, Cost of training technicians, Labor costs
Cost of Non-Conformance	Cost of wasting time, Cost of faults, Cost of spare parts, Labor costs, Cost of poor diagnosis	Cost of wasting time, Cost of spare parts, Labor costs, Cost of poor preventive maintenance

Figure 13: Cost Matrix for Truck OEM, based on the matrix on figure 3 (Salonen and Deleryd, 2001, 68)

5.1.2 Benefits

This thesis work has been a real challenge when considering benefits and value. These two terms have been of a big confusion to almost all the interviewees as they perceive them as being the same thing. However, in the work, it was stated that the value is actually the difference between the benefit and the cost. Therefore, in this analysis section, a clear separation between benefit and value will be provided.

Starting with what the truck OEM perceives as benefits. It has been discussed that pre-diagnosis done on the truck is very beneficial for the truck OEM as it increases the satisfaction of the customer and which is valuable for the OEM. In addition to that, there are checkpoints; when, the truck comes to the workshop, the dealer has some sort of check points that they have to cover when doing the service. These check points are time consuming as much as they are costly. However, the truck OEM can see the benefits of changing or even completely removing some of the check points if they have not been reported any problem concerning that specific check point over the time. This will lead to less time spent in the workshop and also less cost and therefore it increases the value at the end. Another benefit is the uptime, as the truck OEM promises its customers with a specific percentage that it wants to reach in uptime. Therefore, this implies a more satisfied customers and more loyal one. Also the fact that the truck OEM owns all the tools and trained technicians, the work in the workshop becomes more quick and easy and this affects the customer satisfaction once again. Finally the truck OEM benefits from the parts that the dealer buys in order to perform the maintenance service.

5.1.3 Value

In this section, value will be analyzed based on the core components discussed previously and that are the cost and the benefit.

Christopher and Gattorna (2005) stated that customers have become more value conscious than they were before. This implies that companies that enter the market with premium prices

using their reputation cannot survive anymore, since other companies can offer the same value with lower price. This then necessitates a deeper focus on the two main elements of value: benefit and cost. The concept of value, as being the difference between benefit and cost, can vary depending on the interlocutor and interpreting it wrong can lead to undermining the whole business effort. In that sense a common mistake that firms do is to jump into a process assuming that the concept of value is clear and need no further attention (Costa, 2014). So, in order to generate or increase value, firms should focus on maximizing the benefits and reducing the cost as shown above.

The truck OEMs dealer stated that workshops are part of their biggest turnover and they have good network service. Training mechanics and doing diagnoses is part of their biggest cost. Therefore, value for them is that customers' satisfaction is more important than cost. Also, based on a time study done by the truck OEM, value adding time is relatively high when compared with waste time in Sweden in comparison to other countries as the table 4 in the empirical section shows.

These findings lead to questioning the waste and how it could be reduced. Therefore, another study was made to conclude what are the waste elements and how they are divided based on which one generates more waste than the other. Table 5 in the previous section shows the top five wastes based on their percentage.

When asked about what actions could be taken to reduce waste, rescheduling the tools' position was the first thing that was brought up. Actually, taking the tools and leaving them back creates the most waste, so a recommendation was given and that is positioning the tools closer to the repair bay. Another waste stated is movement, and that stands for the movements the technicians do in the workshop and which concerns mainly the layout of the workshop. Therefore, not many actions can be taken to reduce the waste in this case. Finally, trying to diagnose the break down is also part of the waste to which unfortunately not many actions could be taken, unless the technicians could know what to fix in the truck in advance.

However, in order to reduce these wastes or to increase the benefits, the truck OEM should balance between the waste that influences the customer as and the waste that only influences the internal cost. The truck OEM should start with eliminating the waste, and that in this study turned out to be affecting the maintenance, in a sense of increasing the customers' turnarounds and downtime (tools and movements), and poor maintenance (diagnoses). Figure 14 below summarizes the benefit, cost and value elements from the perspective of the truck OEM.

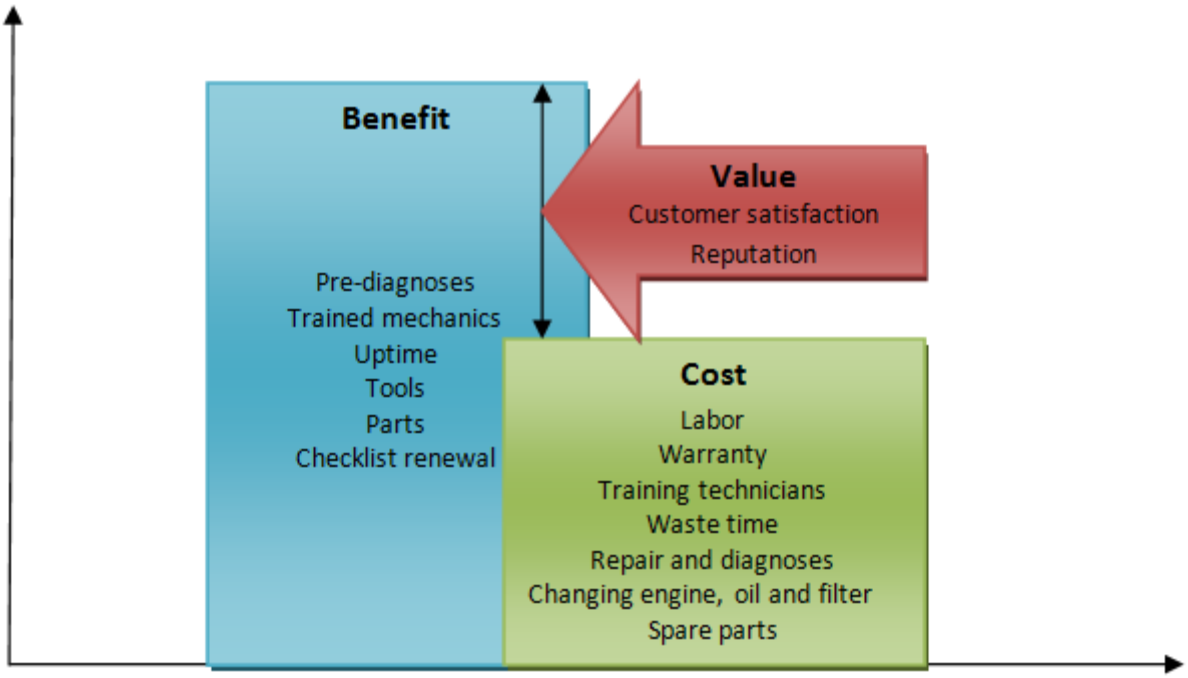

Figure 14: The elements of cost, benefit and value from the truck OEMs perspective

5.2 Perspective of Transport Providers

In this section, empirical data which has been gathered from three different transport provider companies will be analyzed based on the theoretical framework that is given above.

5.2.1 Costs

According to the framework that is provided by Salonen and Deleryd (2011) regarding cost, from transport providers' perspective, it has been analyzed that the cost of service contracts is considered as cost of conformance. Since the transport providers that have been interviewed all have big fleets and buying maintenance services for most of their trucks through the service agreement is more cost efficient. Therefore, they cannot avoid this cost. From their perspective, labor cost and cost of spare parts are not the types of costs that they have to pay directly as long as the contract covers all types of repairs. Transport providers pay only monthly fee, and labor cost and spare parts cost are the aspects that the workshop owners should deal with. However, if service agreements do not cover some certain type of repairs, labor cost and spare part cost turn out to be the cost of conformance for transport providers.

On the other hand, when the truck is new and the warranty still covers all the repairs, transport providers prefer to work with authorized workshops. But when the warranty expires, then the providers tend to work with non-authorized workshops for damages and repairs, in order to reduce their cost of conformance.

From transport providers' perspective, time is another aspect that is calculated as in their organizations. And transport providers are very strict about their timing and schedules. If, workshops have lack of spare parts during the planned maintenance activities; it affects transport providers' business directly. The cost that occurs due to time wastes in the workshops is definitely the cost of non-conformance. Nevertheless, it is not possible avoid from this cost completely. It can only be reduced as minimum as possible by using better planning methods in the workshops.

Another interesting aspect regarding cost has been analyzed as drivers' behaviors. One of the transport providers has argued that their vehicles have big idle times, in other words, the engines are run by the drivers but vehicles do not actually operate for that specific amount of time. This behavior of the drivers causes to need maintenance more often and increases the maintenance cost for the organization. This cost can be considered as cost of non-conformance and can be reduced by educating the drivers appropriately. The cost matrix including the cost aspects of poor maintenance for transport providers has been provided below on figure 15.

- **Cost of Poor Maintenance**

As it has been discussed above, the framework about poor maintenance that is improved by Salonen and Deleryd (2011), suggests dividing poor maintenance into two aspects which are poor preventive maintenance and non-accepted corrective maintenance. According to the empirical data that is gathered from the first transport provider, poor maintenance is mainly experienced due to the poor skilled technicians in the workshop. Therefore, they have both poor preventive maintenance and non-accepted corrective maintenance experiences in the workshops. Since it affects their schedule of transportation and causes waste time, poorly skilled technicians also increases the cost of non-conformance for transport providers. One way to avoid from this problem is training the technicians and improving their skills depending on technical requirements of the trucks. However, this cost is not considered significant for the first transport provider.

The second transport provider argues that poor maintenance is experienced when either the technicians could not fix what had to be fixed on time in the case of damage, or they miss some of the checkpoints during the planned maintenance. Therefore, this transport provider has also experiences regarding poor preventive maintenance and non-accepted corrective maintenance. However, the provider does not see a big problem about this experience as long as the truck is replaced by another truck and they can go on with their business. Because, the cost that occurs due to poor maintenance is totally a non-conformance cost and the provider avoids from it.

The third transport provider states that they do not accept poor maintenance from their suppliers, in the case of any kind of poor maintenance experience; they stop the contract with the particular supplier. And they do not have poor maintenance in their workshops either. Therefore, for the third provider, poor maintenance is not considered as an issue in their organization.

	Corrective Maintenance	**Preventive Maintenance**
Cost of Conformance	Cost of spare parts and Labor cost (If contract does not include some repairs)	Cost of service contracts
Cost of Non-Conformance	Cost of wasting time	Cost of wasting time

Figure 15: Cost Matrix for Transport Provider, based on the matrix on figure 3 (Salonen and Deleryd, 2001, 68)

5.2.2 Benefits

The three providers mainly prefer to outsource the maintenance activities as they want to focus on their core business. The first transport provider stated that outsourcing is less costly and therefore more beneficial, while the second transport provider stated the same adding that the benefit is also focusing on the core business, avoiding the ownership responsibility, avoiding fluctuation on labor cost in the different countries and also avoiding fluctuation of maintenance cost. The third transport provider agreed with the other two transport provider in a sense that outsourcing the maintenance reduces the risk of ownership, and also helps focusing on the core business. It is also cheaper to lease the trucks rather than owning them and it is less responsibility. However, the third provider still owns some trucks just in case of a problem happening with the leased ones, but for them it would be good if they could work with a supplier to whom everything could be outsourced and put KPIs only to measure how the work is going.

5.2.3 Value

When it comes to value of maintenance, the transport providers agreed on the fact that running the truck effectively and having breakdowns is the main key. Also they added that it is of big value that the trucks have fast turnarounds in the workshop and low downtime (when the truck does not perform). In addition to that high productivity is also what they seek from the maintenance service.

So in order to balance the benefits and costs, they want to reduce the maintenance time, in other words, they are looking for squeezing regular maintenance time in order to increase the utilization. They also perceive the outsourcing of the maintenance as a less investment on capital, and that balancing the cost with the benefits of maintenance is part of the fleet management itself. Last, outsourcing the whole maintenance service is only of good as one provider stated that having KPIs could determine their satisfaction. Figure 16 bellow summarizes the benefit, cost and value elements from the perspective of the transport provider.

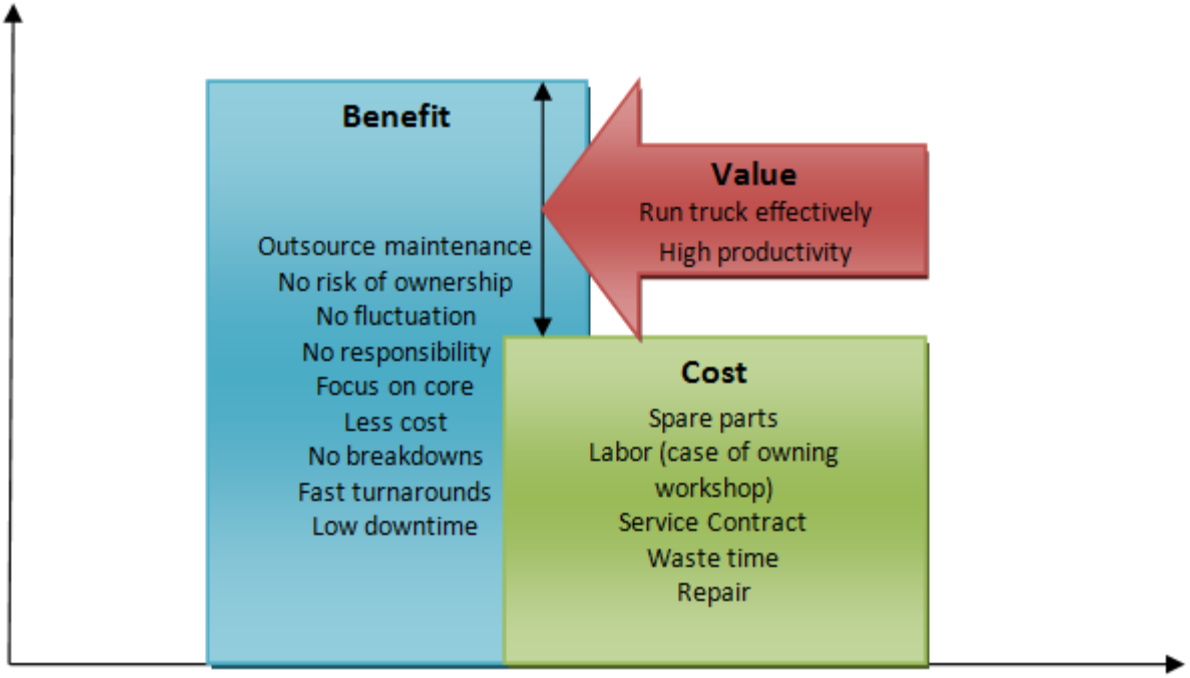

Figure 16: The elements of cost benefit and value from the transport providers' perspective

5.3 Comparison of Different Perspectives

This section is about a comparison between the truck OEM's and the transport providers' perspective regarding cost, cost of poor maintenance, benefits and value of maintenance. It will touch upon the two main sections of value which are benefit and cost separately with a comparison as well from the two different perspectives.

5.3.1 Comparison of the Costs

Based on the framework that is provided by Salonen and Deleryd (2011), when truck OEM and transport providers' perspectives are compared, it has been analyzed that some cost aspects should be considered cost of conformance, while the other aspects are not conformance cost for both perspectives at the same time.

First of all, the cost of service contracts are accepted as cost of conformance for both truck OEM and transport providers. Since offering service contracts are beneficial for the truck OEM, in order to increase efficiency and effectiveness regarding maintenance, they have to deal with this cost. On the other hand, customers with big fleets also consider service contracts beneficial for their business, since they do not have to keep track of all cost aspects separately, it is easier and more efficient for them to pay monthly for maintenance and not to take any responsibility. Therefore cost of service agreements is an important cost element that both sides have to consider.

Warranty cost is another cost element which is cost of conformance for the truck OEM but not for the transport providers. The truck OEM has to offer warranty to their customers, in order to keep customer satisfaction on a certain level and to compete with their competitors in the market. Therefore, the warranty cost cannot be avoided by the truck OEM.

The cost of preventive maintenance and the cost of corrective maintenance are the aspects that the OEM should be in charge of in the cases that transport providers have service agreements. However, when the providers do not have service agreements or they have service agreements but they do not follow the planned maintenance schedule, then the cost of corrective maintenance is considered as cost of non-conformance. In this case, the transport provider should pay for the corrective maintenance cost.

The cost of training the technicians is another cost aspect which should be paid by the truck OEM. Transport providers should not deal with this cost aspect. On the other hand, the cost of changing engines is conformance cost for the truck OEM depending on the service agreements. If customers have service agreements, then the truck OEM should pay for changing the engines. However, if the providers do not have service contracts, then changing the engines turns out to be a cost of conformance for transport providers.

Time waste is calculated as a cost aspect in each perspective. However, it has been analyzed that it is a cost of non-conformance for both sides. If the OEM cannot perform maintenance activities in the promised timeframe, then they have to compensate for this cost to their customers. However, as it has been argued by one of the transport providers, even if the OEM replaces the truck, the time waste still occurs and it still affects transport providers' business. Therefore, both sides pay for this cost anyhow. And it has been analyzed that the cost of wasting time can definitely be avoided or at least reduced by using better planning methods.

The other cost aspects in terms of maintenance cost are labor cost and the cost of spare parts. Labor cost and the cost of spare parts are not the cost elements that transport providers pay directly. Transport providers pay only monthly fee for maintenance and the cost of spare parts and labor cost should be calculated and handled by truck OEM. These two cost elements can

actually be reduced however, it is not possible to avoid from them completely. However, if the service agreements do not include some certain type of repairs, then transport providers have to pay for the cost of spare parts and labor cost which means the two cost aspects turn out to be the cost of conformance for them in this case. When the warranty is expired or the service agreements do not include particular repair operations, transport providers tend to work with non-branded workshops in order to reduce their cost.
And lastly, one of the transport providers has mentioned about drivers' behaviors as an aspect that increases the total cost of maintenance. However, this cost element is completely related to the transport provider and it is a cost of non-conformance. The cost can be reduced by educating the drivers and the truck OEM does not have any responsibility on this cost element.

- **Cost of Poor Maintenance**

Based on the framework that is improved by Salonen and Deleryd (2011), poor maintenance can be experienced either as poor preventive maintenance or non-accepted corrective maintenance. When truck OEM's and transport providers' perspectives are compared, first of all, technicians with poor diagnosis skills or poor skilled technicians in general causes to have non-accepted corrective maintenance. However, this gives a cost that the truck OEM should handle. Transport providers are not supposed to pay for the cost of wrong diagnosis. It is a cost of non-conformance for truck OEM and it can be reduced by educating the technicians.

On the other hand, even though the technicians are well trained, they might still miss some checkpoints when performing maintenance and it addresses to poor preventive maintenance. This also gives a cost of non-conformance to the truck OEM. And it can definitely be avoided. Transport providers are not the responsible of these mistakes and the providers should receive a replacement truck or another kind of compensation in these cases. However, in this case, giving a replacement truck to the providers brings out another cost for the truck OEM that they have to deal with, even though it is a cost of non-conformance. In addition to that, even though the OEM compensates the time waste, the providers still have a negative influence of poor maintenance on their business that they want to avoid from completely.

5.3.2 Comparison of the Benefits

The benefits that the transport providers perceive from outsourcing their maintenance activities go hand in hand with what the truck OEM perceives beneficial to have or do. So to start with the transport providers, they want to focus on their core business which is the fleet management and want to have the maintenance service done by a supplier without affecting their shipments.

First of all, the transport providers want to have no break downs when running their trucks, they want to avoid responsibility of ownership since it implies taking care of whatever comes with the truck. Also, they want to avoid the fluctuation on labor cost around the world and the fluctuation on maintenance cost in general. Leasing trucks can even be cheaper, but then most of the transport providers want to have a backup and therefore they own some trucks in case there would be any problem with the leased ones. Also, fast turnarounds in the workshop and less downtown are very important.

So, for the truck OEM, they will have to provide the maintenance services and repairs as the transport providers decided on shutting down their workshops. In other words, the truck OEMs have the maintenance power and increasing the service will just increase the transport provider's will to work with them. Since the truck OEM works on predicting diagnoses, looks into increasing the uptime, owning all the tools and well trained technicians, they are meeting

the transport providers' needs and reaching their value. However, the question remains how satisfied is the transport provider today and how to increase his satisfaction?

5.3.3 Comparison of the Value Perceptions

Comparing what is of value for the truck OEM and what is valuable for the transport providers is that mainly the truck OEM wants to satisfy their customers and also want to become their best business partner. The truck OEMs reputation is what makes their value while it is the aftermarket that is profitable for them.

When it comes to the transport providers, value for them is running their trucks effectively, meaning no breakdown caused by poor maintenance. Also, spending the lowest time possible in the workshops when doing maintenance is valuable for the transport providers. In other words, fast turnarounds and low downtime are much appreciated.

In order truck OEM to keep their reputation on a high level and make profit in the aftermarket, they have to consider customers' needs in a way that can increase customer satisfaction continuously. In order to do so, the truck OEM should focus on reducing the poor maintenance.

The table 8 represents a summary of the findings from the perspectives of the truck OEM and the transport providers, including the maintenance types, the benefits, the costs, the value and the balance between the value elements.

Table 8: Comparison between truck OEM and transport providers

	Truck OEM and dealer	Transport providers
Objectives	• Truck OEM's service schedule • Uptime	• Outsourced maintenance
Preventive	• Predictable • Wear and tear (less predictable)	
Corrective	• Fault frequencies	
Value	• Reputation • Customers' satisfaction • Best business partners • Relationship • Brand name • Aftermarket is profitable • Fast turnarounds in workshop • Low downtime	• Run truck effectively • Higher productivity

Benefits	• Predicting diagnoses • Predicting what should stay/change/remove on the checklist • Uptime • Tools • Trained technicians • Parts • Labor (dealer)	• Outsource maintenance (less costly) • No breakdowns • Focus on their core business • Avoid responsibility of ownership • Avoid fluctuation on labor costs in different countries • Avoid fluctuation on maintenance cost • Reduce risk of ownership • Leasing is cheaper • Less responsibility
Cost	• Checkpoints • Wear and tear • Repair • Real cost of service contracts • Training mechanics • Diagnoses • Warranty	• Service contract cost • Repair • Commission cost • Spare part cost • Labor cost (owned workshops)
Cost of poor maintenance	• Fault in the parts • Wrong diagnoses • Waste of time	• None (compensation) • Time waste
Balance cost and benefit	• Reduce checkpoint	• Reduced time for maintenance(squeeze regular maintenance time for increasing utilization) • Less investment on capital • Fleet management • Outsource everything to a supplier and keep KPI's for measures
Future	• Service on road • Design for maintainability • Automation	• Electric: less maintenance • Battery Management Service • Decrease total cost of maintenance • Faster and visible

5.4 Consequences for the Truck OEM

In this section the cost aspects will be evaluated and the consequences of reduction for some aspects will be analyzed for the truck OEM. Based on the analysis that has been given on the previous section, some of the cost aspects have been considered as cost non-conformance and it has been discussed that it is possible to reduce them.

One of the most important cost elements to decrease is the cost of time waste. Cost of time waste actually addresses to both non-accepted corrective maintenance and also poor preventive maintenance. In terms of corrective maintenance, if the problem cannot be solved by technicians at the first time and customers visit the workshop for the same problem for the second time, then this cost belongs to the truck OEM and it should be avoided. On the other hand, regarding poor preventive maintenance, if technicians miss some checkpoints during preventive maintenance therefore do not replace the parts that are needed to be replaced, then customers will have to visit workshops before their planned next visit and this cost also should be avoided.

Another aspect to reduce is the cost of spare parts. When the technicians are not able to fix the problem but they replace the parts with the new ones without knowing the real problem increases the cost of spare parts on corrective maintenance. When we talk about preventive maintenance, in some cases, technicians replace the spare parts before their lifespan is over and it is needed. This approach also increases the cost of spare parts and it should be avoided.
The next aspect is the cost of poor diagnosis and this is actually one of the main reasons of increasing the cost of spare parts and labor cost. In some cases, technicians are not able to diagnose the real problem, they tend to make an assumption and do the maintenance based on their assumptions which is not efficient to solve the real problem. Cost of poor diagnosis is a very important aspect that should be reduced in workshops.

On the other hand, in some cases, even though technicians can diagnose the real problem and they actually know how to solve it, a fault can occur due to their poor hand skills and the cost of faults is another element to reduce in workshops. Also the cost of poor preventive maintenance has to be reduced.

According to framework that is provided by Salonen and Deleryd (2011), when the cost of non-conformance is reduced in organizations, even if the cost of conformance is increased comparing to the initial situation, the value as an outcome will increase and the total cost will decrease eventually. Implementation of this framework on the empirical data is given on Figure 17.

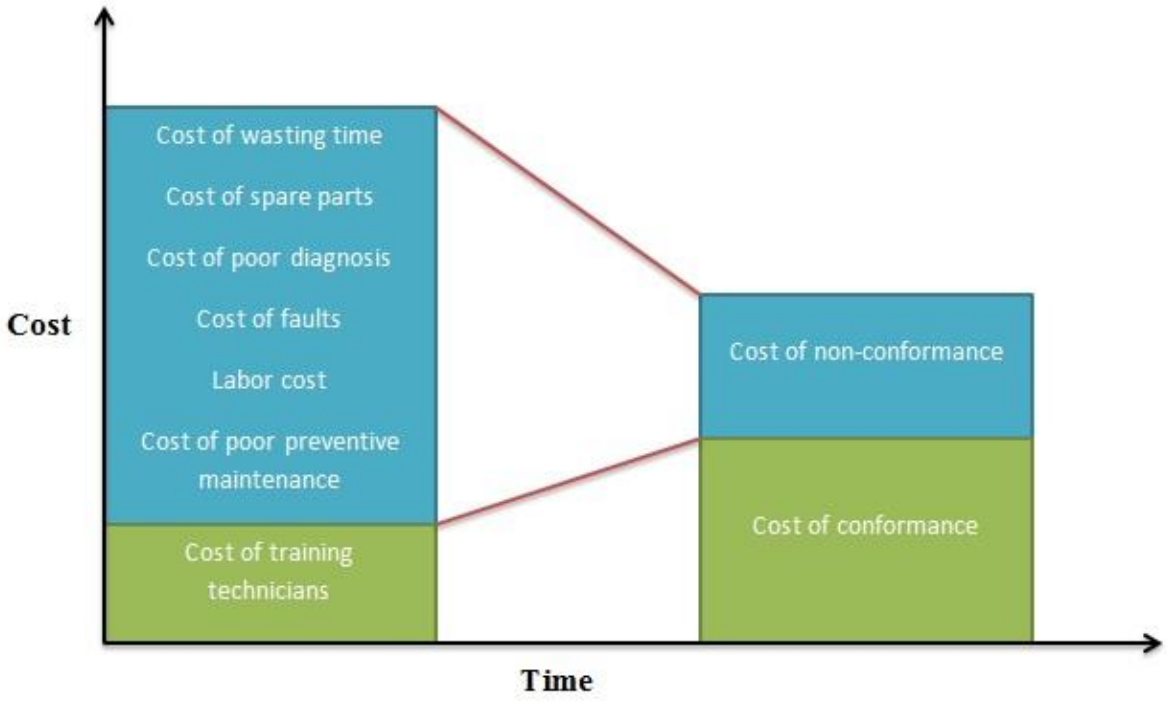

Figure 17: Reduction of cost of non-conformance, based on the matrix on figure 3 (Salonen and Deleryd, 2001, 70)

In this sense, the cost elements that should be reduced have been analyzed above. In order to reduce them, it is recommended that the technicians should be trained more, so that the cost of poor diagnosis, cost of spare parts, costs of faults, cost of poor maintenance, cost of time waste and labor cost could be decreased. It has also been discussed that the benefit of increasing the cost of training technicians will surplus its cost, thus the value will be increased.

6. DISCUSSION

This section includes a discussion about the future technologies from the perception of the actors included in this thesis work and that are the truck OEM and the transport providers. It also includes a discussion about how the truck industry can be influenced from the other industries and that are the railway and the aircraft industries.

6.1 Future Expectations Regarding Maintenance from the Actors' Perspective

Future expectations regarding maintenance have been discussed with the truck OEM, the dealer of truck OEM and also different transport providers. In terms of future alternative propulsion systems for trucks, electric vehicles have been chosen as a possible concept in the future.

The truck OEM sees that overall maintenance will decrease when using electric vehicles with batteries, since there will be no filter or oil changing in engines. However, batteries do not have long lifespan and they have to be replaced in a shorter period comparing to diesel engines. Batteries are way more expensive than diesel engines, in some cases, even more expensive than the truck itself; therefore it is not seem cost efficient in current situation. On the other hand, if the industry is improved and can produce batteries with a longer lifespan and lesser cost, then it could be an option to switch to this new technology for all the trucks. And unfortunately, the managers do not see it coming in the next 20 years.

When electric vehicles are in common usage, some kind of maintenance should be provided by the truck OEM in order to keep uptime as high as they have for diesel engines. Regarding maintenance of electric vehicles, it has been discussed that there will be no need to change oil and filters in the engines, however the maintenance requires advanced knowledge and also isolated areas in workshops. The value that can be generated out of this change is that no oil drains will be observed in workshops, so it provides a cleaner working environment for technicians. Apart from changing filters and oil, maintenance for rest of the truck will still be the same. So, in future, maintenance will still be needed, even though trucks are more advanced.

From the dealer's perspective, maintenance for electric vehicles is not considered hard or dangerous; however it requires an advanced education. When electric vehicles are used in general, the manager discusses that it will be less break downs in trucks, thus less maintenance will be required. Another future expectation regarding maintenance is that using a more effective maintenance management approach. The current system works as when there is a problem about the truck, customer brings the truck to the workshop and technicians diagnose the problem first, then they book an appointment for the repair in 2 days later, in order to order the spare parts meanwhile. However, it gives 2 days of waiting time to the customer, and in the future this process should be improved and the waiting time should be decreased in order to increase customer satisfaction.

Also, in the future, it is expected that more parts could be suitable for repairing apart from replacing. In the current situation, changing engines is the most time consuming operation in workshops. Therefore, the manager discusses that if some parts of engines could be repairable, then there would not be a need to replace the engine because of a small problem, in other words, this improvement would decrease the operation time in workshops. Performing repair more than replace will become more important in the future.

From transport provider A's perspective, since batteries that can produce enough power for electric vehicles are way too heavier than the diesel engines, using batteries will decrease the load capacity in trucks and give a negative effect on their profit margin. In order to integrate batteries into the trucks, they should be improved more comparing to the current ones. In terms of maintenance for electric vehicles, the manager states that it will only change the monthly fee that they have to pay for maintenance, since they do not perform maintenance, investing on tools and education is not their responsibility.

Transport provider B argues that implementation of electric vehicles would actually decrease the total cost of maintenance. The manager also states that comparing to the vehicles with the same size, maintaining electric vehicles has 50% less cost. However, it has also been discussed that using electric vehicles in the current situation would decrease the load capacity since the batteries are too heavy.

Transport provider C discusses that, since maintenance is not their core business, they would not invest on any tools or equipment. Activities should be carried on by truck manufacturers or suppliers. Therefore, the manager does not have a specific expectation regarding maintenance of electric vehicles. However, he has future expectations regarding maintenance in general. He expects that maintenance in the future should be performed faster and also maintenance in workshops should be visible by customers. He discusses that customers will appreciate it if they could watch what is happening in the workshops and have a dialogue with the technicians.

In terms of future expectations, it has been discussed by the authors that electric vehicles would be beneficial in the future when batteries are more developed because in the current situation, batteries are too heavy and this technology will decrease the load capacity of trucks which is not beneficial for transport providers. On the other hand, regarding maintenance, the truck OEM should invest on tools and training technicians since this new technology requires advanced knowledge. It has also been discussed that electric vehicles will not require maintenance as much as vehicles with diesel engines since batteries do not include filter and oil. Therefore, when batteries have a longer lifespan and are less heavy, using electric vehicles will decrease the total cost of maintenance; but with the current technology, using electric vehicles might be more costly in terms of maintenance. Apart from the expectations for electric vehicles, another expectation is improving the current maintenance management system in order to reduce waiting time for customers in workshops thus, increasing the customer satisfaction.

6.2 Influence from the Other Industries

When it comes to comparing the truck industry with the other industries, and from the interviews held in the truck OEM and with other industries, it can be discussable that the truck industry is influenced by these industries but to the same extent.

Railway's and aircraft's first concern is safety, the railway industry does not want the train to stop in the wrong time in the wrong place as it might happen in the night and in the middle of nowhere; while the aircraft also do not want to have an unplanned stop at any point of the time as it difficult to handle. However, unplanned stops in the truck industry do not affect the safety of the driver as he can park to the side and wait for help.

The truck industry is already having some functions that were inspired from the other industries as duplication of some parts for pack-ups as engine duplication in the aircraft.

However, the duplication in the aircraft industry is made to keep safety of the passengers on top, while in the truck industry duplication is made on the speed signals as it is connected to the drivers' safety. On the hand, in the railway industry, increasing the uptime can be very costly and since there is no harm to passengers' lives to do so, it is preferably better not to do so in order to avoid over repair. Both railway and aircraft have strict regulations concerning the maintenance, while in the truck there are no legal requirements that prevent stand stills.

Therefore, having the truck industry performing maintenance at the same level as the railway and the aircraft is not coming in the near future at least, as the truck industry has to balance the benefits and the costs of doing so. So, as long as the truck standstills do not affect the driver's life, the truck industry will not increase the maintenance level of their trucks to reach the same maintenance level of the other two industries. Since the safety of the driver as being the only priority and the only valuable factor for increasing the maintenance level, is already met through the current maintenance activities. The truck industry perceives the costs of increasing the maintenance level exceeding the benefits, as the benefit is to have no standstills while the costs are the cost of duplication, cost of replacement and cost of over-repair. Figure 18 shows how these elements can be balanced and how the costs exceed the benefits.

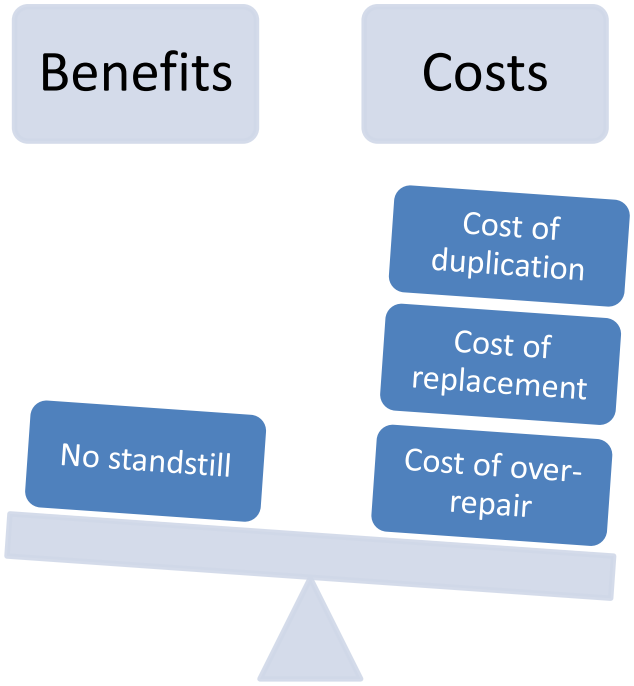

Figure 18: Balancing costs and benefits of reaching the maintenance level of railway and aircraft industries

6.3 The Transport Industry from Supply Chain Perspective

As explained before in the analysis section of the consequences on the truck OEM, reducing the cost of non-conformance by reducing all the costs related to the poor maintenance, will generate an increase in the cost of conformance (training the technicians). Also, as discussed before, the cost of conformance can be increased if the purpose is to decrease the cost of non-conformance; as long as the total cost for maintenance within the truck OEM decreases.

A decrease in the total cost will generate an increase in the value of maintenance for the truck OEM. Since the truck OEM's value is related to the satisfaction of their customers, this implies an increase in the customers' (transport providers) value. The transport providers'

value of maintenance which is generated from high productivity and effective truck running can be increased by having more skilled technicians in the workshops, which the truck OEM should invest more on.

From a holistic view and from the supply chain perspective, decreasing the total cost of maintenance will generate and increase in the value of maintenance for the truck OEM, which will then engender an increase of the value of maintenance for the transport providers. For a more holistic view of where the value will increase, the chain that includes the actors presented in the network of the figure 9 explained in the method section, can be repeated in this discussion section under figure 19 to provide clearer explanations.

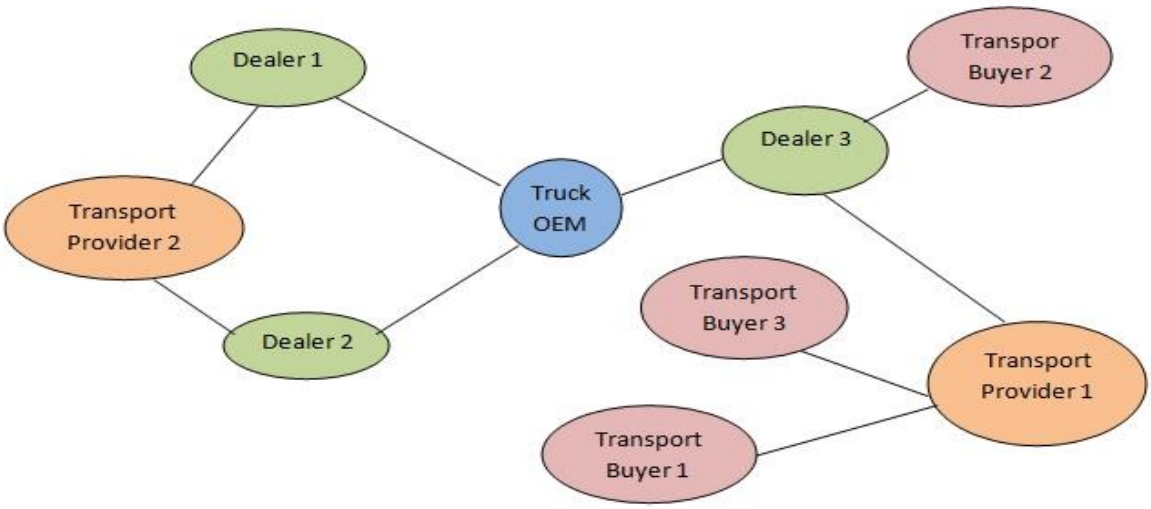

Figure 19: Network of the actors

As the value of maintenance for the truck OEM will increase, the value of the dealer will also increase. However, since the dealers are considered as an extended arm to the truck OEM, the value of its maintenance will not be considered. However, since the truck OEM perceives the satisfaction of their customers (transport providers) as priority and as the most important element of their value, the value of maintenance for the transport providers will also then increase as the truck OEM will increase the cost of poor maintenance which is the main concern of the transport providers. This will also imply an increase in the transport buyers' value as they tend to by the transport service from the transport providers. As a result, increasing the value for one actor will affect the value of the actors in the chain; and therefore, the value will further increase in the chain.

On the other hand, some paradoxes have been discovered during the research. According to Håkansson and Ford (2002), there is a paradox in networks between actors about influencing each other. While one strong actor is trying to influence other actors in the chain, the specific actor can also turn out to be the one who is influenced by the other actors. This thesis work has proved that even though the truck OEM is one of the strongest actors in the chain and has a wide network of workshops all over Sweden, in some cases; their customers prefer non-authorized workshops over authorized workshops that are provided by the truck OEM. And the main reason for this preference has been found out as cost. In spite of having a better reputation in customers' perspectives, the truck OEM does not have the absolute control over workshops and is influenced by non-authorized workshops, because non-authorized workshops provide cheaper maintenance service when it comes to small repairs.

Also, another paradox derives from involvement issues as Håkansson and Ford (2002) discussed. The truck OEM sees their dealers as an extended arm of their company, and they have a share from the profit margin of spare parts that are used in workshops. However, when it comes to allocating labor cost, the truck OEM does not take any responsibility about it and the dealer handles that cost.

7. CONCLUSIONS

In the scope of this master thesis, answers for three research questions have been investigated regarding maintenance. In order to conclude this thesis work, the balance between the benefits and costs as being the basis of value creation and increase has been studied as a tool. The balance of these two elements has been analyzed from both the truck OEM's and the transport providers' perspectives. However, in order to reach this balance, the cost elements have been studied in more depth in order to have a better understanding of how value can be created or increased.

The analysis has shown that the cost elements such as cost of time wastes, cost of spare parts, cost of poor diagnosis, cost of faults, cost of poor preventive maintenance and labor cost should be decreased in order to increase the value of maintenance operations. On the other hand, it should also be discussed that these cost elements corresponds to the concept of poor maintenance based on the analysis. Therefore, reducing this cost aspects in truck OEM will not only increase the value of maintenance activities, but will also mitigates the risk of having poor maintenance experiences in workshops. In order to reduce the aspects, it has been recommended that investing on training technicians will be an efficient approach, even though the cost of training will increase, the value of maintenance will surplus this cost in long term.

Relating this study to the supply chain, a decrease in the non-conformance cost inside of the truck OEM, will decrease the waste of time and stand still for the transport providers and therefore increase their value. By increasing the value of the transport providers, the value of the truck OEM will also increase as it is related to the satisfaction of the customers and also their reputation among their competitors. This will eventually generate further value increase for the other actors in the network, and provides a holistic view over the whole chain.

When it comes to future expectations of actors regarding maintenance, it has been discussed that the overall maintenance cost is expected to decrease when electric vehicles are used in transport industry, since batteries do not require filter and oil change. However, batteries are way too heavier comparing to diesel engines, and it will actually decrease the load capacity which affects the customers' profit margin. Electric vehicles are not expected to be in common usage in at least the next 20 years. And also in terms of future expectations, it has been discussed that more parts should be repairable and the trend should switch from replacing parts to repairing them in the case of a breakdown. Another important expectation for the future is that having a better maintenance management system and decreasing the waiting time for customers as much as possible.

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APPENDIX I

Questionnaire for the Truck OEM:

1. How do you consider maintenance in your business model? What are the maintenance objectives for your company?
2. According to literature, there are 3 types of maintenance system; Run-to-failure, preventive maintenance and condition-based maintenance, can you evaluate about which one or ones the truck OEM applies? If you use more than one, which one do the customers prefer most? And which one is more costly for the truck OEM?
3. Why do you think some of your customers prefer to use their own workshops?
4. How do you define maintenance cost? What are the cost elements?
5. What are the maintenance activities that bring the biggest revenue to the truck OEM? And can you also mention about the most costly maintenance activities?
6. What are the benefits of maintenance activities for the customers?
7. How do you think the customer perceives value?
8. What kind of values could be created in order to increase customer satisfaction? And what kind of feedbacks/criticisms do you get from customers regarding maintenance activities?
9. What is "poor maintenance" from your perspective? Can you give examples regarding poor maintenance?
10. What kind of actions do you take in order to improve "poor maintenance" experiences?
11. Do you think poor maintenance has a considerable cost for your organization? If yes, how do you compensate this cost?
12. If we consider new technologies (mainly electric vehicles), what do you think customers' future expectations would be regarding maintenance?

Questionnaire for the Dealer of Truck OEM:

1. How do you consider maintenance activities in your business model? What are the maintenance objectives?
2. Between preventive and corrective maintenance operations, which one do you see more profitable for your workshop? And which one is more valuable for your customers?
3. What are the most time consuming operations? Do you think it is possible to reduce the operation time for those activities?
4. What could be the most difficult break downs to repair? And how much time (and also cost) do they take approximately?
5. How do you define poor maintenance? And which cost elements do you consider when you think about poor maintenance?
6. What kind of disadvantages/dangers do you see about the maintenance of electrical engines?

7. What are the biggest non-value adding operations? And what kind of actions do you take in order to improve them?
8. When we talk about the value of maintenance for customers, we talk about what they perceive as being important (from these maintenance activities). So what do customers care about the most when it comes to maintenance then?

Questionnaire for Transport Providers:

1. What are the maintenance objectives for your company?
2. Do you use your own workshops or the truck OEM's authorized workshops? Why?
3. If yes, according to literature, there are 3 types of maintenance system; Run-to-failure, preventive maintenance and condition-based maintenance, can you evaluate about which one or ones you opt for? Why do you prefer them? And which one is more costly?
4. How do you define maintenance cost? What are the cost elements?
5. What are the maintenance activities that bring the biggest revenue to you company? And can you also mention about the most costly maintenance activities?
6. What are the benefits of maintenance activities for you?
7. How do you perceive value?
8. What kind of values could be created in order to increase your satisfaction? And what kind of feedbacks/criticisms do you give regarding maintenance activities?
9. What is "poor maintenance" from your perspective?
10. If we consider new technologies (mainly electric vehicles), what do you think your expectations would be regarding maintenance?