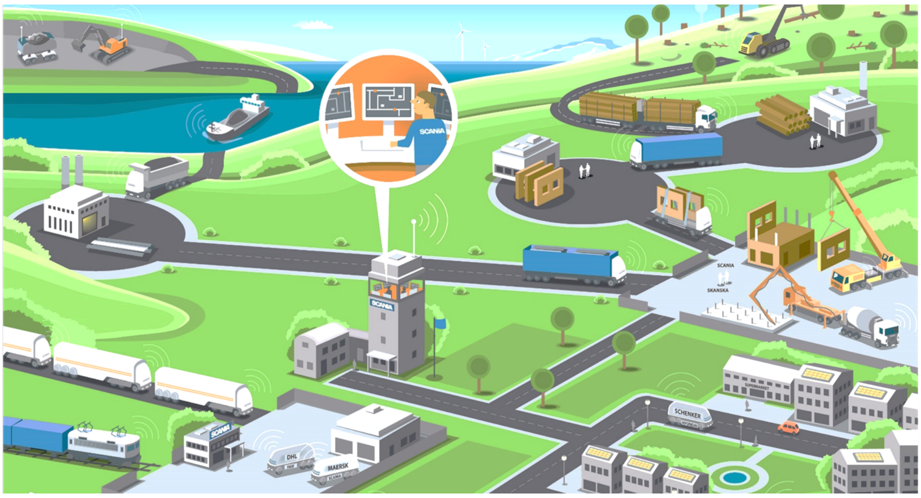
DEGREE PROJECT

Future Logistical Services from Connected Vehicles

A Case Study at Scania CV AB



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ABSTRACT

The road based transportation operations are growing rapidly, but the current infrastructure cannot sustain the entire growth. At the same time vehicle utilisation and fill rates are low. Improved efficiency of the operations is a necessary way forward for road based transportation. Parallel to this, heavy vehicle producers are currently improving the efficiency with services accompanying the product that are focused on the driver and the vehicle performance. However, the data from connected vehicles required for these services only entail a small amount of the operational data generated by connected vehicles. The case study aims to answer how to use connected vehicle operational data in order to suggest value adding services in a dynamic road distribution system. The applied methodology is an inductive study with an explanatory approach to map the current and future service offerings of the case company. This knowledge is combined with an exploratory approach with interviews of transport planners and theories of Lean and fleet management. Primarily, it is concluded that the perspective of operational data requires widening. Considering not only driver and vehicle operations but rather the entire transport operation of a company. It is also concluded that value creation with operational data is possible during three phases of fleet management. First, if knowledge about order data is accessible, the planning of transportations can be improved using route optimisation and operations research. Secondly, it is possible to create value during the execution phase, through less manual supervision and communication by transport planners. Lastly, both the currently used operational data and further data usage can contribute to a better understanding of the performance of a fleet operation and facilitate for continuous improvements during an evaluation phase.

PREFACE

Our work with this research has come to a conclusion. It has been the most rewarding time at the university and we are grateful for the support we have received from our mentors Björn Samuelsson and Peter Lindeskoug and would also like to thank all other participants for their valuable comments and inputs.

During the extent of this thesis the rapidly developing area of digitalisation of vehicles has advanced further. In May 18th Scania announced the release of their new service Trailer Control which included information such as temperature, axle load and trailer position in their Fleet Management Portal. This is an improvement of the current services, as we conclude in this work and an important step towards a more comprehensive fleet management system. Also, there is much exciting new research being conducted at Scania, however in our report we have chosen to leave out some parts which have resulted in a slightly more condensed report.

Lastly, it is with great appreciation we hand our work over to Scania CV AB and Luleå University of Technology.

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VOCABULARY

Body – The part of a heavy vehicle built on the chassis, normally by another body building company, in order to transport the goods protected from the surrounding environment.

Connected Services – A group of services from Scania based on connectivity from connected vehicles. Divided into two subgroups *Fleet Management* and *Tachograph.*

Connectivity – The state and means of being connected to a network.

Ecodriving – Driving with attention towards a low as possible fuel consumption primarily with awareness for the environment but also fuel related costs.

Fill Rate – The rate at which vehicles are loaded in relation to either their weight or volume capacity.

Fleet Management – if not general definition then: A subgroup of Scania *Connected Services* subdivided into three offerings *Monitoring Report*, *Control* and *Data Access Package*.

FMP – Fleet Management Portal, a web- and application based portal as part of the *Connected Services* and *Fleet Management* offering.

FMS – Fleet Management System, the communication interface that enables services of *FMP* and based on the *Position based Operational Data.*

Onboard – A term referring to the vehicle system in opposition to *Offboard* which refers to the server system outside of the vehicle.

Operational data – Consists of all information sent from a connected vehicle. The data is categorised into two groups: *Diagnostic Operational Data* and *Position based Operational Data*

RTC – Short for Road Traffic Communicator. The electric control unit enabling for connectivity with mobile networks, either 2G or 3G mobile networks.

Tachograph – An instrument recording consecutive the driving hours of a driver in order to force adherence towards road regulation.

Tier customer – The different levels of customers in a supply chain. A customer of a customer is referred to as *tier-two customer*.

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1 INTRODUCTION

The three drivers of global change; digitalisation, globalisation and urbanisation, define the rules for future business whilst continuously creating new opportunities and difficulties. Globalisation eradicates distance as a trade barrier and enables global competition. Digitalisation creates new medium and new conditions for business and communication. With urbanisation, population density rises and dependency on goods produced outside of urban areas increases. These drivers together are contributing to a larger transport demand. This entails more complex and more widespread supply chains and increased importance of transportation.

Following a growing consumption of products, transportation accounts for in average twenty percent of product value is an expanding market (Henriksson, 2017). Increased complexity in a global supply chain raises the difficulties of supply chain and fleet management. Large vehicle fleets transporting small number of goods per vehicle in complex systems with flexibility of route choice makes it difficult to manage road transport logistics (Rodrigue & Slack, 2017). Furthermore, Rodrigue and Slack (2017) point at a relatively low cost of market entry and limited economies of scale of road transport, which allows for many competing road carriers. All in all, Kloster and Hasle (2007) concludes that transportation management has been performed inefficient since vehicle planning has been performed manually with a lack of coordination as a result. Fangel (2017) and Falkstrand (2017) furthermore contribute road transport inefficiency to driver autonomy and maverick behaviour. Symptomatic for this is Henriksson's (2017) claim that the average fill rate in Europe is 60%. The road infrastructure can however not expand in the same pace as the supply chain demand and the necessary way forward is instead improved efficiency in transportation (FFI, 2015).

With digitalisation, more and more devices are interconnected. Much of the long-distance connection is through wireless networks and already implemented wireless telephone technologies such as 2G, 3G and 4G. Vehicles connected to a mobile network have existed during all different generations and have enabled different functionalities. The technology development enables new communication opportunities for driver, vehicle, goods and infrastructure to communicate with each other in real time (FFI, 2015).

By connecting vehicles to a wireless mobile telecommunication network, information could be collected and deliver knowledge over vehicle fleet and supply chain status in order to create fleet management systems. Digitalisation and connectivity would increase the possibility for road carriers to improve their business in a gradually urbanising and globalising world and for vehicle producers to develop their service offering further.

1.1 PROBLEM DESCRIPTION

In 2015 Scania produced and sold 69 762 trucks worldwide (Scania CV, 2017). Previously industrial manufacturing have had a strict production focus; however, with bigger competition and decreasing margins, there is a shift toward including a larger service focus (Atlas Copco, 2016; Callenryd, 2017). Since 2011 Scania has therefore connected their vehicles in order to expand their service portfolio and create value for their customers (Lindskoug, 2017). Scania currently have around 250 000 connected vehicles operating worldwide (Henriksson, 2017).

Scania has since the 1980's actively implemented Lean philosophies into their operations, resulting in Scania Production System and increased productivity and quality, decreased energy consumption and maintained production costs (Palmgren, 2014). This continuous improvement philosophy and culture has proven efficient not only in the production (Svedlund & Wiberg, 2009) and Scania aims to develop this competency into a service offering of continuous improvements and value creation for transportations customers (Fangel, 2017).

The connected Scania vehicles transmits operational data to Scania which encompasses variables among others; position, speed, heading, and fuel consumption. The utilisation of this operational data is currently limited to the fleet management system, diagnostic readouts by Scania vehicle maintenance and Scania research and development (Lindskoug, 2017). A significant amount of the operational data is thus not being used to its full potential. Used more efficiently the data could assist road carriers to improve their work processes and be value creating. It is therefore of interest for Scania to further explore utilisations areas of the operational data from a supply chain perspective and investigate how this data can add value by improving transport operations.

1.2 RESEARCH PURPOSE

Currently Scania is delivering value adding services through improved transport operations in selected, fenced in and reoccurring road transport utilisations such as mining, farming and forest industry. The purpose of this report is therefore to complement this knowledge by using connected vehicle operational data to suggest value adding concepts in a dynamic road distribution system.

RESEARCH OBJECTIVE

To use connected vehicle operational data to suggest value adding concepts in a dynamic road distribution system.

RESEARCH QUESTIONS

- What are the current Scania transportation services, both available and under development?
- What does the operational data consist of and how is it generated?
- How can the identified services be improved using operational data and/or new sources of information?

DELIMITATIONS

This report is delimited to consider a road transport distribution system with dynamic transport demands on public roads. The focus will be broad and not limited to the actions of a driver but from an overhead transport perspective. The data considered is the operational data available from connected Scania vehicles; however, evaluating if any additional external or future internal data references could further be value adding for customers is also of importance and considered. Lastly, from a logistical process perspective the thesis will be limited from the planning of road carrier service until the execution plus evaluation, which is shown in Figure 1.

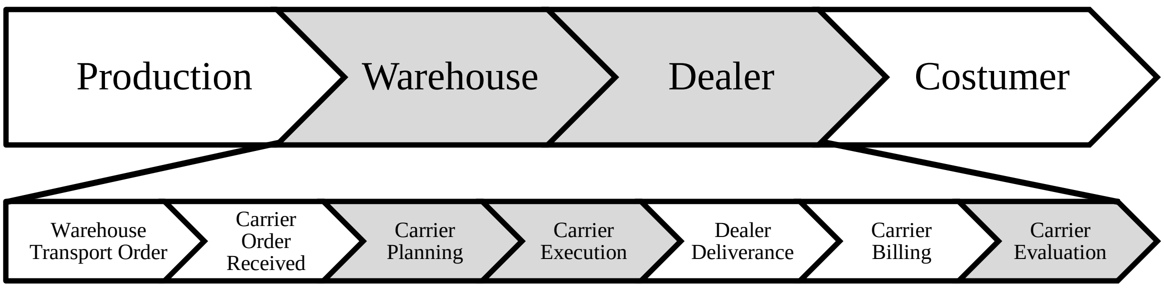

Figure 1 – Delimitation in the logistical process

2 RESEARCH METHODOLOGY

With a wide and a significant part of the objective based not only on an understanding of the topic but also on how surrounding coherent activities and components relate to the topic, an inductive research approach was chosen for this research. Lacking of existing specific theory regarding the research questions, required the formulation of a theory built from research from the bottom up, which is in cohesion with an inductive approach. Furthermore, due to the restriction of time and the broad problem definition the research requires an inductive approach which is suitable for small data sets that cannot be validated quantitatively. A cornerstone in this thesis was to gain an understanding of the operational data from connected vehicles and the current usage of it. Further exploratory purposes could therefore not be considered until that understanding was complete. The resulting formulation was therefore both descriptive and exploratory. A single case study was used as a research strategy since the comprehension process had to be made in real context through observations and interviews.

2.1 DATA COLLECTION

Primary qualitative data was collected through semi-structured interviews and observations both internally at Scania and externally with Scania customers. In order to first gain an understanding of the order process, observations at and interviews at customers was an important part of the customer contact. The ambition was to gain a broad insight into road carriers managed their transport operations and what their challenges in achieving improved performance. The ambition had however to be in relation to the limited time available for interviewing customers. Although, the ambition was never not to be able to draw any valid generalisations from the road carrier population. The ambition was rather to give an insight into the operations and challenges in a qualitative manner in order to facilitate the creativity process associated to research question three. The selection of road carriers was based on small to medium sized companies working within distribution as main business. The sample was a version of convenience sample where customers were contacted through recommendations from Scania maintenance market vendors. The sample of face-to-face interviews were also selected based on convenience to reduce the travel time. In total three types of non-standardised interviews were conducted: two face-to-face with Scania customers, six telephone interviews with Scania customers and two Scania maintenance market vendors. The interviews were conducted during three days and after all eight interviews were done, the notes were discussed and summarised.

The face-to-face interviews were conducted semi-structured with transport planners according to the questions in Appendix 1. The questions were sent in advance in order for the interviewee to be able to prepare. The questions were initiated with closed questions and then continued with open questions all in a logical order to lead into the more relevant questions. Together with the interviews, observation at the same companies were made. Specifically, the order process was observed, from incoming order to a planned and ready transport route. Both visits lasted one hour and were conducted with one interviewer asking questions and one taking notes.

The interviews over telephone were conducted in a similar manner for both service market vendors and customers, although referring to different questionnaires, seen in Appendix 1. The questionnaire was not sent out in advance and there was also a variation in the structure of interviews due to different time allowances from the interviewees, where in certain cases only a couple of questions could be asked and in other cases the questions could be asked exhaustively. The interviewees were either transport planners or associated with the management of the company with varying responsibilities within distribution planning. The interviews lasted between ten and thirty minutes. The interviews were conducted with both group members, one asking questions and one taking notes.

The case study on Scania consisted of semi-structured interviews, non-structured interviews and a workshop combined with and secondary data. Eight semi-structured interviews with key project managers, researchers and other relevant personnel from different departments at Scania were held in order to map and understand the current research and project developments. These interviews answered both research question one and two by contributing to insights on how operational data is used within different settings outside the delimitations of the research. They were selected based on snowball sampling with recommendations from previous interviewees or the mentor at Scania. Each interview lasted in average one hour. Furthermore, multiple non-structured interviews were conducted with the Scania mentor and employees in the same department, mostly in informal settings. The secondary data consisted of different reports and technical descriptions of the electrical system on board vehicles and other relevant project information. During the data collection phase, a document was used to gather potential ideas related to the third research question. Everything with a chance of being important for the analysis were documented.

On the 28th of March about 15 Scania employees attended a half-time presentation. After the presentation, the participants were divided into three smaller groups with different competence. Each group had at least one with knowledge about the operational data. The groups got the two questions from Appendix 1 to discuss for 15 minutes. The groups documented the discussions on paper.

The literature review was based on the search of the following search words in order to find relevant theoretical information: Transport Management System, Operations Research, Route Planning, Vehicle Routing Problem, Stochastic Vehicle Routing, Dynamic Vehicle Routing, Lean, Logistics, Visualisation, PDCA; Supply Chain Coordination, Time Utilisation, Fill Rate. The search engines applied was Ebsco and Google scholar and each cited article was reviewed for peer review and number of citations.

2.2 ANALYSIS METHOD

The analysis of this thesis was divided into two phases. The first phase took place during the data collection. All new information was continuously analysed and compared with the existing information. Each interview and observation with customers were discussed amongst the authors and key perceptions were highlighted. The aim of this phase was to do shallow analysis to be able to guide the research in the right direction. The result from this phase was a list of all ideas that was agreed upon to contribute to the research objective.

The second phase of the analysis was done when all data was collected. The phase started with a deep and thorough analysis of the already gathered suggestions. This time with a wider knowledge base and more time allowance for creativity and problem solving. This phase included going through all available electric control unit families that were available to discuss new possible usage areas, see Table 1.

2.3 VALIDITY AND RELIABILITY

During the data collection, there has been validity and reliability uncertainties. The three parties; researchers, customers and Scania personnel have all understood the questions differently and also all have agendas and are in different ways bias. Both conducting and asking the type of questions needed to get the right information is interviewer bias due the fact that the answers were desired, even if the questions were to be objectively formulated. The interviewee might have been affected by external factors such as stress or having colleagues listening to what answers are given. Since the case study was based on qualitative interviews, the error margin decreased due to less dependence on the answers since no generalisation was made based on them. The interviewees were selected based on opinions and tips from Scania employees. To find the right interviewees and interview enough managers and customers for this research requires more resources than what was available and is a deficit in the validity of the research. The interviewed customers had answerers that were potentially incomplete because they felt uncomfortable discussing somewhat sensitive company secrets such as work methods or customer related information. The interviewed Scania personnel had different reasons for not giving complete and honest answers. One reason could be not trusting master's thesis students with research secrets and another being their interest in promoting their own project to give a better picture than the reality or being bias towards their own project. Improvement of the validity was ensured by interviewing a large number of customer in order to understand a broader but not generalizable picture. Furthermore, the validity was also ensured by sending the questions in advance in order for the interviewees to be able to prepare and give answers more closely related to the research. It was also strengthened by conducting a triangulating analysis supported by three different information sources; literature, customer needs and Scania research.

The reliability of any inductive case study is low concerning the repeatability of the method. Especially since the results are influenced by time and a repeated research will have a different outcome in the future. Furthermore, other contacted road carriers' answers will not likely be similar. The interviewed customers were also not completely objective even when they were aware that they were both anonymous and not recorded. The consequence of making the interviewee anonymous made it difficult to trace the source of information affects the reliability. However, reliability in the aspect of conclusions is relatively good. Because if a similar study is conducted with triangulation from customer, employees and literature in order to gain a basic understanding of the challenges and opportunities and would analyse the operational data similarly, the likelihood of similar conclusions are probable.

3 LITTERATURE REVIEW

3.1 LEAN

Lean is a philosophy for a long-term organisation toward a, for the customer, value creating process by continuously eliminating waste and inefficiencies in the process (Sayer & Bruce, 2007). In order to force a new position from business as separate entities in a supply chain and traditional batch production toward the value chain as a whole and process focus Womack and Jones (1996) suggest a Lean thinking framework of five steps: specify value, identify the value stream, create flow, use pull and work toward perfection. They argue that all these steps will shape the organisation and thinking towards creating value for the customers by eliminating wasteful activities.

A fundamental starting point according to Womack and Jones (1996) for Lean is to define value accurately. The opposite of value creation is waste or *muda* in Japanese which in Lean philosophy means any activity that uses resources but does not create any value for the customer (Womack & Jones, 1996). However what value is differing from context to context and can therefore only be defined and meaningfully expressed as a customer's need for a product at a specific price and time (Womack & Jones, 1996). Therefore, the authors argue that Lean thinking must start by defining value in terms of specific customer needs. Although, when asking customers what they want, they often answer with variants of what they are getting today or return to simpler formulations such as lower cost, faster delivery and higher quality (Womack & Jones, 1996). Instead Womack and Jones (1996) argue that in order to reach a better definition, value should be analysed by challenging traditional means of working and advanced definitions. Furthermore, customers often just look at their own needs, instead of thinking of the whole value chain were value often is created.

When value is defined Womack and Jones (1996) suggests streamlining the organisation towards only working with what creates value. More precisely identifying the activities that are *value adding*, *necessary but non value adding* and *non-value adding.* Where non-value adding activities are neither necessary nor value adding and in theory should be removed first from the process. All the remaining activities should then be managed to achieve flow, which often require a change in mind-set, an example of such a change being from make-to-batch to make-to-order (Womack & Jones, 1996). Another often common required change is to not consider the current tools for achieving customer value since these might be designed for economy of scale and cannot deliver flow without unnecessary waiting time (Womack & Jones, 1996).

Lastly Lean thinking is about seeing the benefits in cooperation and transparency in working towards perfection. According to Womack and Jones (1996) much of the *muda* created in business is results of protectionist reasoning and an atomistic thinking. By being more transparent and sharing information the authors mean that waste between companies can be identified and removed and the profit shared between the companies and the customer. Aside from finding intercorporate waste Lean thinking also facilitates visualisation of processes internally in organisations. Bicheno and Holweg (2009) highlight examples of waste related to logistical services: overproduction (not used transport capacity), waiting, movement, inventory, defects, time, variation, information duplication and unclear communication.

Lindskog, Vallhagen, Berglund and Johansson (2016) found through visualisation that risks and problems associated with the planning process could be avoided. When they in their process aimed to define a Lean production environment different areas were covered in order to eliminate waste in the flow of material, handling of material at nodes and infrastructure for maintenance. The result of visualisation as a tool was a large confidence in the planning process and timesaving in planning and execution (Lindskog et al., 2016). Visibility of performance mandatory for any Lean implementation (Bicheno & Holweg, 2009). A method for visualisation of a logical flow is Value Stream Mapping (VSM), a Lean methodology to efficiently satisfy customer demand with short lead times (Lindskog et al., 2016). Lindskog et al. (2016) also point to the 5W2H method as a method to complement VSM when visualising a process. 5W2H are the questions; why, when, who, where, what, how and how much posed in order to comprehend the purpose of an activity.

Continuous improvements and risk management is an important part of Lean implementation (Lindskog et al., 2016; Womack & Jones, 1996). Lindskog et al. (2016) point out the LAMDA model as an important tool in achieving continuous improvements and risk management, however; Schmidt, Elezi, Tommelein and Lindemann (2014) lifts the Plan, Do, Check, Act (PDCA) cycle as a foundation for continuous improvement. According to Bicheno and Holweg there are important considerations in each step of PDCA. Plan is to understand the customer and their requirements, define a detailed time plan and set common goals for the achievement, check relates back to the defined goals in plan and is important to carry out frequently with discipline. Lastly act is the part of improvement action toward fulfilling the goals completely. All together the PDCA method for improvements embraces the philosophy of *kaizen* (Bicheno & Holweg, 2009).

3.1.1 PERFORMANCE MEASURING

According to Bicheno and Holweg (2009) measurement is waste in Lean, it should be limited and minimized. General qualities of measurements should be indicators of problem, contribute to the improvement loop by surfacing problems and focus on improvement. Measures accodring to the authors should not be motivational but rather informational in order to assist in improvement. Furthermore there are four neccesary types of measurements in Lean: lead time, customer satisfaction, schedule attainment and turnover rate of inventory (Bicheno & Holweg, 2009). Durak and Akdoğan (2016) compiled performance measures used by studies of logistic companies into: Delivery time, quality, consistency, productivity, sales costs, production time, delivery security, service quality, flexibility, market share, customer loyalty, activity, efficiency and conformance to standards. Two important measures to further consider in performance measuring in supply chains are vehicle time utilisation and vehicle fill rate (Samuelsson, 2017).

3.1.2 SUPPLY CHAIN

Looking at a single company improving and streamlining their operations toward only creating customer value is not optimal, Bicheno and Holweg (2009) claim that large dysfunction can accumulate if each company and actor in the supply chain focus on their own improvement. Such a focus can give rise to increasing variations of interpreted demand and accumulation of uneven production and wasteful inventories (Bicheno & Holweg, 2009). Preventing such a supply chain behaviour according to Lean can be achieved through shared incentive systems and defining the shared supply chain strategy (Bicheno & Holweg, 2009). Digitalisation also facilitates implementation of Lean since it enables immediate distribution of demand data along the supply chain and smart factories can also produce faster and customized products (Netland, 2015).

According to Bicheno and Holweg (2009) there are two main strategies for a supply chain, either efficient or responsive. They have furthermore summarised three threats to a Lean supply chain: Inventory and delay, uncertainty, number of actors. These are according to Bicheno and Holweg (2009) managed with correct information or they cited Michael Hammer: "Inventory is a substitute for information" which is interpreted as with bad or no information and uncertainties inventories are used instead. Information of actual sales and forecasted demand allows for better alignment of resources and future strategic capacity planning (Bicheno & Holweg, 2009). In multimodal transportation, which is the case of almost any supply chain, Jarašūnienė, Batarlienė & Vaičiūtė (2016) mean that the large flow of information and diverse parameters between transports require efficient communication systems to manage a material flow. Other means of tackling ineffective supply chains are according to Bicheno and Holweg (2009) by making varying and infrequent deliveries as frequent and regular as possible similar to the "milk-round" strategy. With a frequent and set route and time slots for delivery reduces amplifications and variations and fosters a steady and efficient flow with reduced lead times (Bicheno & Holweg, 2009). Bicheno and Holweg (2009) also emphasize the opportunities with a very frequent service interval with small batches in a well-planned manner to ensure a high fill rate in the vehicles. Well planned operations are important to reduce waste and create customer value, but is a complicated procedure not easily accomplished by manual computing.

3.2 OPERATIONS RESEARCH

Operations research is a branch of applied mathematics used to analyse, describe and find different means of action in technical or economical decision problems (Lundgren, Rönnqvist, & Värbrand, 2003). It is according to Gass and Assad (2005) a scientific tool for management decisions regarding their operations in a quantitative manner. The science was first utilised during the second world war, thus the name Research on (military) Operations (Lundgren et al., 2003). This analytical tool is also named operational analysis and is used to find the optimal solution to quantitatively expressible problems. More specifically operations research can make a decision based on a problem proposition with a defined target and limitations (Lundgren et al., 2003). Transport and logistics is a common area for operations research. It enables planning of travel routes and resources such as trailers, vehicles and personnel. This research is important for supply chain actors in order to increase the efficiency of distribution of goods (FFI, 2015). It has a higher potential for efficiency increase than for example improved fill rate would have for distribution carriers (FFI, 2015).

Vehicle routing problem (VRP) is the scientific title of the operations research segment that involves defining a target of minimizing the overall transportation costs whilst reaching all target destinations (Lundgren et al., 2003). The model then evaluates all different routes based on the cost incurred at each option. It originates from the traveling salesmen problem (TSP) which is a demanding operations research problem. It belongs to the most difficult class of mathematical modelling problems which are non-conclusive in polynomial time (Kloster & Hasle, 2007). Kloster and Hasle (2007) therefore claims that there is no algorithm that can solve a VRP to optimality. There is however possible to solve the VRP problem exactly below the threshold of 50-100 orders using different heuristic models (Kloster & Hasle, 2007). Within the limit, however; VRP has proved very effective in reducing waste in supply chains, applying VRP modelling will reduce costs of transport by 5-30% (Kloster & Hasle, 2007).

VRP is however only the simplest model for supply chain application, research is focusing on enhanced compatibility to reality through vehicle capacity constraint

(CVRP), driver working restrictions (DVRP) and order time windows (VRPTW) (Kloster & Hasle, 2007). Further additions can be how to load vehicles for optimal unloading a category of operations research called bin packing problem (Lundgren et al., 2003). CDVRP is a problem with constrained load for each vehicle and constrained time or distance for each vehicle or driver, but does not consider time windows for deliveries. VRP however require much and well-prepared information before usability. In the above example numbers of drivers and vehicles, exact order information with time-of-delivery, location and dimensions and weight of goods is required for an optimal calculation. It also requires a careful formulation and calculation time. Dudas et al. (2015) speculate in that when order data is missing it could be possible to analyse quantitative historical data in order to detect the operational flow of road carriers. This would enable route optimisaiton in hindsight and identification of improvement areas such as logistical bottlenecks, vehicle deviations and benchmarking (Dudas et al., 2015). When defined, however; modelling within the same definition is possible to perform within minutes depending on the size of the dataset. Operations research enables a scientific perspective of transports in supply chains and is an important tool for efficient transportation system management (Lundgren et al., 2003).

3.3 FLEET MANAGEMENT

Fleet management encompasses technology and processes related to a vehicle-based system. Combining data logging, satellite positioning, communication, vehicle-, maintenance-, driver- and transport management with a IT system creates a fleet management system (Fagerberg, 2016). A fleet management system is therefore a management tool used to acquire control over dispersed fleets and enables road carriers to systematically manage risks of fleet reliability and controlling the cost of such reliability (Galletti, Lee, & Kozman, 2010). Galletti et al. (2010) concludes that the risk of fleet ownership causes many businesses that require heavy vehicles for their business to outsource it. The authors mean that fleet management is the management type responsible for attending to these risks and require risky business. There are more than 4,5 million fleet management systems installed in Europe alone with a forecasted strong increase (Berger, 2016). Fleet management performance is according to Galletti et al. (2010) cost effectiveness and customer satisfaction, which is mainly achieved through reliability in vehicle management.

However, without performance measurements and benchmarking with other businesses the authors mean that the operations will affect cost effectiveness, safety, reliability, service level negatively. Moreover, that there is no ground for continuous improvements if there is no such comparison between businesses. A further outcome of benchmarking is the visibility of poor performance areas which can be improved. The authors also claim that fleet managers lack the standardised methods to achieve optimal fleet decisions. With benchmarking, strategic management decisions can be facilitated (Korpela & Tuominen, 1996). Benchmarking allows for knowledge of where the fleet performance is in relation to customer demands and identifies areas of improvement to continuously monitor the fleet (Galletti et al., 2010). Competitive benchmarking allows for road carriers to compare themselves with other companies in the same specific industry that share the same customer base and is thus the most beneficial (Galletti et al., 2010).

Galletti et al. (2010) suggest a detailed framework for benchmarking fleet management performance. In short, they first propose categorising the cost of fleet operations such as fleet investment and maintenance, drivers and transport planners and then determining what cost is associated with each category. Afterwards the focus of the benchmarking should be established where examples according to the authors can be management, personnel or fleet operations. When current business type and benchmark focus is decided, benchmarking can be initiated and used for continuous improvements.

4 EMPIRICAL FINDINGS

4.1 SCANIA

Scania offers transport solutions were the primary products are trucks, busses and motors. In 2016 Scania sold about 73 thousand trucks, 8 thousand busses, 8 thousand motors and services for 22 billion SEK (Scania CV, 2017). Furthermore, Volkswagen group owns 82,63 % and MAN owns 17,37 %. However, the Volkswagen group directly or indirectly owns all shares and votes. In 2016 Scania's turnover was 104 billion SEK with 10 billion SEK in operational profit. In the year-end of 2016 their total assets were 162 billion SEK. Scania has in total about 46 thousand employees with more than 15 thousand employed in Sweden. Scania's biggest market is Europe but Asia and Latin America are also important markets. Scania's market positioning is with high quality and a high initial cost. However, they have established a mission to provide the best life cycle value on the market and as such services associated with the product are an important contribution of life cycle value to the customers through example a higher utilisation.

4.1.1 SCANIA PRODUCTION SYSTEM

Scania Production System (SPS) is a standardised means of production originating from Lean production and is based on the Scania Way, which is a vision of providing the best life-cycle value for their customers. From that vision Scania has developed values to guide the work in the right direction. The values are illustrated through the well-established Scania House seen in Figure 2.

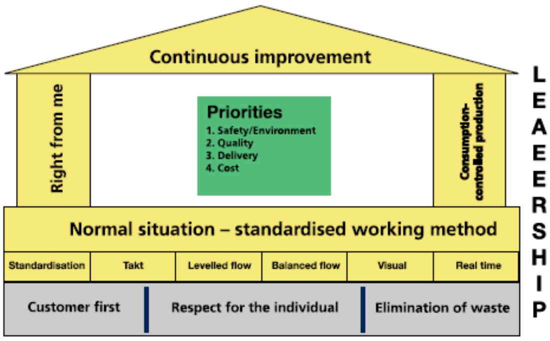

Figure 2 – The Scania House, an illustration of the Scania values.

The three principles *Right from me*, *Consumption-controlled production* and *Normal situation* illustrate the responsibility of the employee to take responsibility in the continuous improvement work, the pull based production system and a standardised approach. The *Normal situation* is based on the principles of standardisation, levelled and balanced flow where progress is visualised and problems resolved in real time. The approach of establishing a current or normal situation visualises any deviations, which if attended to will lead to continuous improvements. A standardisation ensures that all activities are value creating and if new non-value creating activities are identified, they are removed from the standard. With a levelled flow, all resources can be used evenly throughout periods of time and a balanced flow ensures that all activities have an evenly high work load. Visualisation of the process is used to establish the relation between the current situation and the normal situation in order to be able to perceive and respond to deviations in real time.

The SPS contain plentiful methods and means of achieving the Scania Way. An examples is the definition of productivity, where it is stated that a productivity increase not always is positive. In the case that it leads to overproduction another waste is created instead. If continuous improvements instead are focused on cost reduction, it might be possible to reach improvements while at the same time not overproducing. Similarly does a utility not need to be used all hours of the day, but it is necessary that it is reliable and available when needed. SPS also emphasises that increased productivity cannot be achieved in one area since that might negatively affect other production areas, there needs to be a common improvement in order to reach productivity benefits.

Luttik (2017) further developed the concept of SPS and Lean production onto the process of transport. He outlined three steps of improvement:

1) What is the process?
2) How does the process work?
3) How can the process be improved?

He means that initially it is important to gain an understanding of the operations before starting to work towards continuous improvements. Exemplified, this can involve actually riding the transport vehicle and follow the driver throughout his or her day or gaining this knowledge by other means such as videos or illustration of the operation. It is important to create a mirror of reality and experiencing the process, through this knowledge he argues that chaos of activities can be turned into order and understood. The goal when the process is dynamic and changing is to try and find structures within the process that are repetitive in order to establish a standard mode. Secondly Luttik (2017) compares lead time with value adding time in order to gain an understanding of the efficiency of the process and how well it is working. This is done by understanding what processes are value adding and which are not in order to understand how resource efficient a process is. Lastly it is about understanding how this process can be improved through deviations of the normal situation of the process and understanding who the customer is and what gives them value. It is important to understand what is meaningful information to the customer in order to understand the customer need. If there is no insight into the timeliness of transports, resource efficiency is an effective measurement. In the other case, it is also possible to measure waiting time of transports.

Lastly Luttik (2017) concludes that the process of improvement is understanding and illustrating the entire and wide picture of the process and then identifying the bottlenecks of the process. These bottlenecks should be alleviated through focused work and then it is important to control the large perspective and see what influence the solved bottlenecks had on the entire process, this should then be repeated for continuous improvements. Sometimes it is also not always remediating a deviation that brings improvement but rather remediating the pattern of deviations. In conclusion Luttik (2017) mean that Scania should focus on giving the Scania customers the tools for understanding their process and that perhaps Scania can supply information about potential risks in the traffic to road carriers so that risks can be avoided. This information can be collected by Scania from the more then 250 000 vehicles they have trafficking the world globally.

4.1.2 CONNECTED VEHICLES

Connected vehicles are vehicles that communicate through a long distance wireless connection. Information over the vehicle status is called operational data. This information comes from a large set of data such as error or status messages from a multitude of operational variables stored in the logical units throughout the vehicle’s electrical system. However; the system at Scania is currently designed to transmit a smaller subset called position based operational data at a predefined interval. The simplified subset for frequent transmission is called Current Status (CS). This information is transmitted based on different events and times and are defined uniquely for each vehicle.

The complete set of operational data consist of certain different operational variables belonging to differen control units in the vehicle. They are sorted to different buses throughout the vehicle, where some are related to the actual and safe propulsion of the vehicle whilst other are focused on the security, comfort and safety functions in the vehicle. All the different control units are shown in Table 1.

Table 1 – Families of control units in the onboard architecture.

ECU	Description
Coordinator	Electronic module between the engine and some other electronic module. Transfers data from the driver's controls to a system, e.g. the retarder, and also to displays in the instrument cluster, such as that showing oil pressure.
Steering Angle Sensor	Angle sensor that registers how far the steering wheel is turned.
Forward Looking Camera	Camera in the front of the vehicle, which can identify objects, shapes and light variations some distance in front of the vehicle.
Distance Sensor	Electronic control system for reading off changes in distance to objects in front of the vehicle, using a distance sensor as the main component.
Chassis Management System	Electronic control system for chassis related functions.
Tyre Pressure Monitoring	Function for monitoring that the tyre pressures are correct.
Air Processing System	System containing the components in the supply circuit for the compressed air system, i.e. air dryer, protection valve, pressure sensor and pressure limiting valve.
Tag Axle Steering System	System for steering of the tag axle wheels in relation to the vehicle' s direction of travel.
All Wheel Drive	Distribution of propulsion to all axles in a vehicle.
Tachograph	Control unit for the logging and long-term storage of operational data, with a focus on driver-related data, such as driving and rest times.
Road Traffic Communicator	Scania's communication unit in the cab with no driver interface, used for communication between the vehicle and the outside world.
Instrument Cluster	Set of devices in the instrument panel that displays vehicle information to the driver.
Body Work Electrical	System which manages the electrical preparation for the bodywork and bus body, and which provides an electrical communication interface with external bodywork functions.
Visibility System	System for controlling components that affect visibility or attract attention such as lamps, wipers, washers and horns.
Brake Management System	Electronic control system for brake related functions.
Transmission Management System	Electronic control system for gear changing, auxiliary brake and power transmission in the powertrain.
Engine Management System	Electronic control system for engine functions and exhaust emissions
Crash Safety System	System for controlling belt pretensioners and airbags in the event of an accident or a threatening traffic situation.
Climate Control System	Electronic control system for the automatic control of the air temperature, fan speed and air distribution.

Clock Timer System	Electronic control system for the alarm clock, the sleep function and the time display as well as programming times for the climate control and the infotainment systems.
Alarm System	Electronic control system for the detection of someone breaking into a vehicle, including one or more warning functions.
Internal Light	Any lighting on the inside of a vehicle.
Door Control System	Electronic control system for door locking and other functions related to the cab doors.

4.1.3 CONNECTED SERVICES

Connectivity from vehicles a network of services based on information transmitted from a customer's vehicle, where from a customer perspective the most evitable is FMP. There are also other services in Scania that benefit from connectivity in vehicles such as Scania Maintenance and Scania Assistance which can perform remote diagnostic analysis of a vehicle on their way to assist a faulted vehicle or workshops before a scheduled maintenance stop.

4.1.3.1 FLEET MANAGEMENT

Fleet Management Portal (FMP) envelops many of the different services of Scania's offering such as Tachograph and Driver Evaluation. In Figure 3 all the services are illustrated as the menu of FMP. All functions can be categorised into three main services with additional subservices; management of drivers, vehicles and the transport flow.

Within driver management there are communication possibilities, tachograph services and driver evaluation which provides feedback to the driver based on his/her driving. The driver evaluation is designed to develop the driver's expertise in manoeuvring heavy vehicles through personal feedback on performance results such as eco driving and vehicle safety. Where coasting distance, over speeding and –revving and acceleration are example parameters used to grade the eco driving performance.

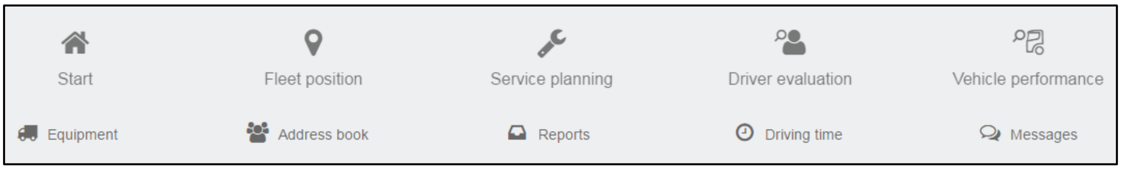

Figure 3 – The menu of FMP

The cluster of services related to vehicle management are current vehicle position, service related and performance reports and a vehicle database. The positions of each vehicle is mapped with information of heading, speed and fuel level. There is a service planning tool that outlines the current status and service need of each vehicle, which allows for service scheduling and planning. There are also different reports of vehicle usage, engine and environmental performance.

The last category of service is the overall all transport flow where all vehicles are mapped and displayed with real time positions of all connected vehicles are available. It is possible to plan single routes and create geographical fencing for notifications or alarms when a vehicle enters a certain geographical zone. The usage of FMP is characterised by high frequency of users using mainly the Fleet Position or functions associated with the Fleet Position function and a lower usage frequency of the other services.

4.1.3.2 Operational Factors

Operational factors are a technical description of certain conditions in different operating environment that affects the vehicle. The factors are operational data used on a higher abstraction level, put in a context and often combined in order to effectively describe the environment in which the vehicles operate. This information is used in the customisation of orders, so that each customer can receive a vehicle built and adopted for the certain conditions that have been aggregated from previous vehicles of customers. The operational factors are in short, a language for expressing and analysing a customer's transport and future maintenance needs.

4.1.4 Current Projects

The Fleet Management Portal is Scania's current main offering of logistical services to their customers, however; they are continuously developing new services to widen their logistic service portfolio. Their projects range from predevelopment research to operational spinoff companies all working to improve heavy transport logistics.

4.1.4.1 DoIT

DoIT is an abbreviation for Data-driven Optimisation for Intelligent and efficient Transports. It is aimed to be a decision support tool for fleet management with the goal of reducing cost by increased efficiency in transportation through big data analytics. The project is separated into two main parts of big data analytics of variables affecting the fuel efficiency on different routes and an assignment planning service. The analytics part involves multiple input data sources affecting fuel efficiency such as vehicle configuration, cargo load, physical conditions including weather and elevation on the transport routes, resource availability in order and calculate the aggregated fuel costs for selecting each route. The assignment planning function follows the principals of an operations research problem, in order to assign each vehicle driver and order in the most optimal manner achievable. The project is currently partly based on analysis of the operational data from connected vehicles, which is anonymised.

4.1.4.2 FUMA

FUMA is short for Fleet telematics big data analytics for vehicle Usage Modelling and Analysis, the project is currently conducted within Scania in collaboration with Fraunhofer-Chalmers Centre. The purpose of the project is to define and develop models of the transport network and study the movement patterns from telematics data. The framework conducted from this project will enable deeper and more detailed analysis of operations and movement patterns from fleets.

4.1.4.3 Scania Site Optimisation

Scania Site Optimisation is a project where Scania takes its Lean production system knowledge and implements it into different Scania customer segments. Primarily it has been concept developed within the mining industry at different mining sites around the world. In principle Scania Site Optimisation is a framework that helps improve logistical operations by understanding, identifying and improving the operations of a specific Scania customer. Through connected vehicles, vehicle data is collected and mapped in order to gain an understanding of the sub processes that the main process consists of. Bottlenecks can be identified and resolved systematically to improve the flow of the process. Scania Site Optimisation focuses specifically on managing and optimising five factors to ensure a sustainable operation. These factors are: Time, Load, Road, Safety, Sustainability.

4.1.4.4 LOTS

LOTS Group, solution engineering is an independent consultant firm owned by Scania. LOTS is founded on the principles of Scania's culture of modular products, production systems and Lean manufacturing and implementing this philosophy in transport industries, much like Scania Site Optimisation. However, they look at transport processes as a part of the entire supply chain system. Gathering information from each sub process gives an understanding of the inefficiencies in the supply chain emerge. LOTS can then visualise the inefficiencies and assist in removing them and thereby eliminate waste.

In practise, their business is separated into two solution concepts, first, they visualise and suggest improvements based on vehicle and external data. Secondly, they offer the previous concept with the addition that they manage the flow of transport also and can gain full control of the operations and aim to perform them as efficient as possible. An important data source is thus the operational data and thanks to their independency from Scania they optimises transportation using operational data from mixed fleets were information comes from both Scania, Volvo and 3rd parties. LOTS has a highly data driver business idea and much of their logistic optimisation is based on accurate data to eliminate wasteful processes. LOTS as a company is interested in exploring more opportunities of the quantity of data in order to improve their supply chain efficiency further and thereby the competitiveness of their business idea. Falkstrand (2017) emphasizes the importance of the principal of open data where a data owner perhaps not is the most successful in exploring new opportunities related to the data compared to external entities such as LOTS Group.

LOTS thus operate some supply chains for their customers and their interest is in achieving a supply chain with as little waste as possible. When they recommend their customers to purchase they prioritise vehicle producers which have a large set as possible available for them so that they more easily can achieve the benefits of a data driven supply chain.

4.2 EXTERNAL DEVELOPMENTS

4.2.1 CUSTOMERS

Customers within distribution have varying businesses and are responsible for transporting a wide variety of goods that altogether facilitate all the services occurring in the society of today. The interviewed businesses transport goods ranging from gas, liquids, concrete and garbage to museum exhibitions and frozen food. According to the conducted interviews it is today necessary to purchase third-party services in order to manage a distribution business since nothing sufficient is supplied by the vehicle producers. The most common of task such systems is to manage in general driver time and rest, orders, vehicle status and maintenance need, driver and vehicle performance.

One key difference between different distribution companies is if they plan and execute themselves or their customer plans their activates and that they in turn execute the planning. This difference influences the incentives of measuring performance of the operations, as the road carriers executing pre-planned orders are satisfied with less detailed measuring activities. Examples of less detailed performance measurements are timeliness, rough categorisation of vehicle availability and adherence to customer demand and rules. Self-planning road carriers are more meticulous with performance measurements such as financial payoff, fill rate and higher resolution of driver activities around actual driving. As legislation dictates recording of driver time and rest this is a performance measurement available to all road carriers, but used at different extents. Company B is using it to assess the vehicle coordinator performance, however the responsible transport planer at company B claims it does not give a just picture of the actual performance of the planning. Since maintenance and washing activities are not apparent is such a performance indicator. Company A agrees with this and have purchased a system in order to give a higher resolution to the additional activities associated around a vehicle operation. Their system is also necessary to reduce complexity for the drivers since it simplifies the input process, something Company A classifies as necessary as their drivers will not input such information manually otherwise.

Company F measures fuel consumption and timeliness but not efficiency in terms of vehicle or trailer utilisation although they express interest in such information. Also company F expressed issues in measuring the height of vehicles, which requires measuring using a tool that require time and that sometimes is not used or ignored. Company C furthermore emphasizes the importance with simplicity in the on-board systems for drivers and transport planners since it otherwise reduces the contribution of each system when the driver and transport planner knowledge of operating each system is more limited. This opinion of not achieving maximum value from each system was reoccurring among the interviewed companies which often pointed out that multiple third party services as an improvement area. As an example, company D has 30 vehicles and uses five separate services providers. These services sometimes overlap and it is hard to keep track on functions and login-information, especially for drivers.

Further tools important for customers are order management tools where they are either specially developed for a specific business branch or a more general distribution case. For Company C such an order management tool is essential for them in their planning of operations, since with detailed input of load volume and weight gives information as to the remaining capacity of each vehicle and the overall fill rate of the company's vehicles. When measuring performance, it is also important to be aware that a large amount of transportation demand cannot be measured in volume or weight according to company C as they might be transporting art and museum exhibitions. Company F uses no dedicated system for their planning but rather Microsoft Excel and an in-house developed program solely for billing.

For two of the interviewed companies much or the entire operation is planned ahead by their customer who is in turn also responsible for the maximal utilisation of the ordered vehicles. What is important here is instead compliance of customer regulations. In the case of Company C, their main challenge and use of fleet management systems is to supervise that the demands of the customer are met, for example not exceeding 80 km/h. They also demand driver autonomy to make decisions regarding the quality of the roads and ultimately a risk assessment, as they value the waste of higher risk driving as larger compared to accidents.

In company H, each planer spends 2-4 hours each day for daily planning. Company F has two dedicated transport planners that work fulltime in managing around ten vehicles each.

According to company B, C, F tactic and strategic planning is carried out manually. Operational planning is in company B, C communicated automatically where orders appear directly at the driver on board system or planned through the transport planners. Changes in the amount in each order is in company C managed through communication with the transport planner who takes the decisions. However, orders appearing after the planning already is executed is not in general implemented into the current planning but added to the following planning period. Customer B solves their operational stochastic order demands on ad-hoc basis usually by the driver themselves, but their tactical planning is done by transport planners where there is generally lower demand for their ordinary services. Company F uses manual communication of the transport missions through print outs from Microsoft Excel.

4.2.1.1 Service Market Representatives

The service market sales personnel who conveyed the contact details of the contacted Scania customers expressed their understanding of the needs of their customers. Primarily it is important that the number of subscriptions are low, the customers does not appreciate the administration of several subscriptions and adhering passwords and log in procedures. They are convinced that the FMP is an excellent platform for further services deployment and that it would be easier to sell to Scania customers. They also bring up Volvo Dynafleet as a competitor with more functionalities that is appreciated in the lumber industry namely that it can display the current weight of the goods transported. The Dynafleet report tools is according to the representatives also simpler to understand and has more easily comprehensible information.

4.2.2 External Businesses

Similarly to the project development within Scania there is a market of actors whom are also developing services based on operational data from different vehicles, for example Boeing has since long used operational data in their maintenance planning and new aircraft development. Their Dreamliner series, is equipped with a system of sensors connected to engines, wheel, electrical system, batteries and other systems in order to continuously monitor the state of the aircraft. This information is frequently sent to the pilots, aircraft technician and the plane manufacturer (Boeing) (Orring, 2017). The connected airplanes are always sending reports for the developers to continue to perfect the systems and maintenance personnel can access the system remotely before a service stop to be alert on any errors, which shortens and simplifies the maintenance stop (Orring, 2017). The sensor system ranges from the entire aircraft’s different systems and can give information about wheel pressure and battery status.

The company Klimator and the Swedish Transport Administration have equipped 200 taxi vehicles with a similar tool to the RTC that reads signals in the vehicle and gathers information about everything in the vehicle (Nohrstedt, 2017). In specific this project focuses on data such as wheel rotation, outdoor temperature, amount of rain, engine output effect, vehicle displacement and how long the fog lights have been activated. All this information is then compiled to information of the current friction between the wheels and road and whether there is ice forming on the road (Nohrstedt, 2017). The goal of the project is to adapt the road care to where the need is largest and in the future to send road status information to drivers who can adapt the speed and prevent accidents (Nohrstedt, 2017). Klimator is an example of utilisation of operational data. However, there are several more examples of utilisation of data in the transport industry.

4.2.2.1 Vehco Vehicle Communications

Vehco is a third-party service provider that offer similar functions as FMP. Compared with is they use an external mobile device to collect information from the vehicle. This enables customers to use mixed fleets efficiently. Vehco vehicle communications offers a service that in some ways complements and in other ways overlaps with Scania’s services. The key differences are what data the service is built on. FMP is only built on operational data while Vehco additionally uses order information. This enables Vehco to offer functions such as route planning and order processing.

4.2.2.2 K2 Fleet 101

K2 Fleet 101 is also a third-party service provider that simplify the handling of order information from offer to invoice to statistics by integration with customers Enterprise Recourse Planning systems. This enables K2 to be used through the whole transporting chain. It is used to book and plan transports, map and follow ongoing tasks, follow-up, make price suggestions, and print out shipping papers and invoices. K2 is also used to communicate with drivers, customers and subcontractors, from the drivers hand computers back to customer in the same system.

4.2.2.3 Volvo Dynafleet

Volvo Dynafleet is a fleet management tool that can be offered together with a purchase of a Volvo heavy vehicle or installed in other heavy vehicles. It includes several levels of subscriptions moving from driver reports to positioning. The driver report gives information of how the driver has been handling the vehicle in relation to fuel efficiency. Their fleet management system contains load information and Dynafleet can therefore display how heavily a vehicle is loaded. Dynafleet also contain a function of route planning for each order since this route can be displayed on the on-board monitor in the vehicle and the transport planner can also be alerted to any deviations from this planned route. A further additional feature that Dynafleet offers is forwarding information to customers to Volvo customers of the position of their order and an estimated arrival time.

5 ANALYSIS

Each Scania customer makes up a part of a supply chain. A stream of activities enabling a global supply of goods to be delivered anywhere in the world. However, much of the focus on global supply chain has throughout the years been focused on economy of scale. A focus based on the idea that costs should be spread across large produced quantities and high utilisation in order to lower the total costs. This however also has had the consequence of buffer stocks building up between each activity along the supply chain. In addition to large buffers and long lead times, road based transportation systems are exposed to difficulties such as multiple route opportunities for each transport, manual planning, driver autonomy and an increasing amount of traffic of different types, which all accumulate waste in the overall process.

Lean thinking is to continuously work to remove such wasteful processes. In the transportation industry an efficient production should focus on activities that are value adding and on eliminate those that are not. Such an understanding requires information of the current state of operations, which can be found in the operational data of connected vehicles. However, first it is important to understand what information is value adding for the customer and in which context and situation this information is necessary. This can be done through establishing what value is for all actors of a supply chain. One suggestion to achieve this is through information flow where all involved actors in one supply chain, share their respective operational information. Exemplified, certain customers might value timely deliveries, while others value simplicity or low prices. However, if this information does not reach all actors of a supply chain it will create misaligned efforts of value creation. When the same information is not conveyed to the road carrier executing the transport as communicated between a supplier and a purchaser, misunderstandings and a dissatisfaction could occur. Only when the same information is shared between all the actors in a supply chain and there is a common understanding of value, it is possible to work towards improving the supply chain.

There are further four more stages in implementing a Lean supply chain; identifying the value stream, creating flow, using pull and working toward perfection. However, within logistics and especially distribution the process already is similar to pull manufacturing since no delivery is planned or performed without a demand. Although it can be questioned if the process is downright pull since the equipment and availability for transportation is dimensioned after an expected demand and as such available ahead of an expressed demand. Furthermore, a transportation operation is rarely initiated immediately after a single demand has been expressed but rather accumulated to a certain level when economy of scale can be attained. This counteracts pull manufacturing but ensures a high utilisation of the vehicles available for transportation.

Identifying the value stream, creating flow and working toward perfection are nonetheless important. Identifying the value stream, creating flow in those activities and at the same time eliminating activities that are not, is working towards perfection. These activities can therefore all be aligned under the process of working continuously toward perfection using PDCA. Consequently; the cycle can be used as a framework primarily in the *plan* stage to identify value creating activities and eliminating non-value creating activities. The operations characterised by the *do* stage should handle flow and manage deviations. The last stage *check* involves working toward perfection through analysing and evaluating the operations for any wasteful processes. The results from *check* then requires manual *action* towards improvement, something which is not possible to achieve through a FMS which merely can identify improvements. Although, the activities associated with plan, do, check is possible to implement in an FMS. These activities can be associated with the similar logistical activities according to Figure 4. This is thus a structure for continuous improvement. A structure in which it is important to separate the different stages of a process since each has different potential in reducing waste and require different operational data.

5.1 PLANNING

All planning require information. The quality and amount of available information will

Figure 4 – Main parts of a transportation process.

directly affect the opportunity to make optimal use of the resources available. A question that has risen from interviews with Scania customers is whether they in all situations are the optimal receiver of operational data. In some situations, the tier-two customer sometimes have better usage of operational data, and especially if they are the planner of the transport or highly dependent on timely deliveries. In theory, the understanding of who the customer is and who should be the receiver for operational data from connected vehicles is important in understanding which information that should be communicated so that there are ideal conditions for an optimal planning of resources.

Currently, Scania does not possess any information concerning the holistic picture or details of each transport and can therefore neither convey the information of what value is to their customers nor the basic order information. The information Scania possesses is rather the momentaneous and historical picture of the operational performance of each digital control unit in the vehicle. If there is a possibility for Scania to acquire more detailed information of the supply chain the road carrier customer is a part of, it could be value adding for the entire supply chain since a vehicle manufacturer can communicate this information further. The additional information could be combined with the current operational data of vehicles and distributed according to what is meaningful information for each actor in the supply chain. It would enable planning of transportations more congruently with the expressed demand.

Continuing on the topic of information sharing, it is important to consider other aspects of information privacy than the unlimited flow of information. Road bound distribution has in Europe a high competition between different road carriers and information that might lead to decreased competitive advantage and losing customers is sensitive. Therefore, an absolute information sharing requires the consideration of the complex market road carriers operate within. Despite the theoretical advantage of transparency between actors in a supply for better flow and optimal usage of resources much of the business today are built upon restrictive information sharing with competitors. For example, information of one road carrier’s historical positions can be used by another one to compete for the customers in a certain region which will negatively affect the financial result of both road carriers. However, the theories establish that these consequences are expected and that in the long-term actors and the entire supply chain will benefit from information sharing, due to the aforementioned build-up of unnecessary activities and stock. This prevents cooperation and optimal creation of value for the customers downwards in the supply stream. In some aspects, privacy concerns from information sharing are exaggerated since the information vehicle manufacturers actually have possession over does not necessarily have to be sensitive.

Furthermore, the information does not have to be shared on the entire transport market but rather within a single supply chain. Information concerning why and how to transport is also less sensitive compared to information of what, when, where and how much.

The detailed order information of what, when, where and how much each order consist of can provide additional value to customer compared with today. Consider the route optimisation research project DoIT, with the order information available, in theory DoIT can evolve to a route optimisation application. The order information can be used as an input to the mathematical model within DoIT to plan exactly which vehicles, drivers and routes that should be used to operate the business optimally. Assignment planning and route optimisation enables services such as an evaluation of profitability of different customer orders and thus a possibility of selecting tasks based on profitability. Tactical planning, based on the model output can include information of which vehicle size and type is optimal for the business since it will be visible which vehicles the model prefers and how many that is needed when all operations are optimised. However, route optimisation is a modelling of reality and can thus never achieve full functionality due to certain constraints that are present in a distribution business but simply cannot easily be modelled. Still this has large potential to improve utilisation and remove waste from the planning process, since there are evidence of manual planning today. There are also possibilities of strategic planning from analysing how well each hub of a road carrier is placed in relation to its other hubs and the customers it is currently serving. Mathematical optimisation therefore has large potentials in improving supply chains both the short-term planning and support the long-term decisions. Moreover, in the future perspective it is important for heavy vehicle manufacturers to question what gives their customers the most value. In relation to Lean theory of flow it is important to question the equipment road carriers are using currently and in favour of what equipment is most suited for a flow in actual demand from customers. Mathematically analysing the long-term fill rate can give insights in how to shape the tools that will help road carriers in answering these strategic questions.

The collection of order information can be achieved through a couple of means. There is an operational data variable measuring the axle load that gives a rough estimation of the current weight of each vehicle. If subtracted from the known gross weight of the vehicle it is possible to estimate the loaded weight in each vehicle. However, in our interviews it is clear that the information is not sufficient for the purpose of operations research. Despite the opportunity to use the current weight variable there are not any possibilities of accurately estimating the volume in each vehicle ahead of execution, which is required for a full implementation of route optimisation. The potential of the knowledge acquired from FUMA can however be used to speculate of the potential in documenting the sort of transport being performed for certain trips. The opportunity arises when a transport is classified as a certain type, where the average density of the goods can be acquired through identified similarities of transports of the same type. For example, if concluded that the transport is a liquid transport the density of the liquid is already available, these values can be combined with the current weight of the vehicle in order to establish what percentage of the vehicle capacity has been used at a certain time. Nonetheless, this information is only available after the vehicle has been loaded and in transit, which means it is therefore not sufficient for planning of the operation, however; it is sufficient for evaluation.

To acquire the order information by other means ahead of execution there are two ways. First, by integrating FMP with an external Transport Management System (TMS) that some customers are using today in order to manage their orders. Secondly, it can be done by integrating a system for order information input directly with FMP, similarly to Vehco. Eith an integrated order management system, there are more opportunities for Scania to control which input information is required when an order is being registered. As an example the information of why and how a transport is being ordered and should be transported. It would also simplify the process for the customers since all information is managed from FMP, something the customers have expressed is of value to them. However, any of these manners will enable order information to be accessible by Scania before the execution of orders and enables customers to plan operationally and strategically using route optimisation.

In the planning process of a dynamic distribution system, relying on mathematical optimisation is effective in reducing the waste occurring when demand volumes are continuously changing. The theories and Luttik (2017) also suggested a different approach to reduce the waste generated from differences. The proposed solution involves striving to even out the variations which are the root cause of waste. This can be done through offering as a suggestion better prices or shorter response time during hours of low demands. Aiming to reducing the variations in order to establish a state of normality is desirable but not always easy.

Focusing on the potential of order data together with vehicle operational data from connected vehicles there are further value adding potentials. There are currently several online marketplaces for purchasing and selling available transport capacity. With order information from plenty of road carriers available, it is possible to create a database consisting of available transportation volumes. That would enable road carriers to be offered further orders from other road carriers in additions to the ones they have planned. Even though, there are marketplaces available today, none has the opportunity of several road carriers connected to the system automatically. This has potential to improve utilisation and profitability of road carriers further and is value adding for road carriers which can easily receive further orders in the same procedure as planning. Another advantage of the vehicle manufacturer as maintainer of such a database is that in order to get the road carriers to initially share their order information there needs to be an objective external part which can manage the different orders without bias, such as a vehicle manufacturer.

The planning phase is a continuous process that should be able to be adapted as the conditions changes until an order is finally delivered. If any new information becomes available before delivering an order it is possible that the optimal solution changes and the plan should therefore be changed. However, changes to the original planning during execution occurs unpredictably and require another more operative approach.

5.2 EXECUTION

The management of deviations is an important part of Lean thinking and logistics. However, currently there are not any tools for deviation management in FMP. Although, with order information available and a planned route using route optimisation or manual planning, it becomes possible for a fleet management system to manage the current transportation missions in real time. Deviations from the planned schedule and the estimated time of arrival can be evaluated continuously and delays such as unnecessary stops and not optimal speed, detected and displayed as they occur. An intuitive presentation of all current transportation assignments and their status according to the planned state, or normal state as is important according to Lean theories, will enable transport planners to quickly respond to any deviations and solve them earlier and more effective. Today, this is done with time consuming administrative work, such as calling the drivers to check on their progress, looking through the map of FMP for any potential delays, estimating the vehicles arrival time and then comparing to the planned arrival time. This is not efficient, but with order information included in the operational data, improvements are possible. Improvements not only for the drivers but mainly the transport planners and the entire company. Additionally, with the information of the planned route of the vehicles a new sort of geographical fence is enabled, any physical deviation from the route can be detected directly when the GPS position is detected outside of the planned route, routefencing.

During the execution of a transport each vehicle and road carrier is a part of a larger logistical system of other transportations that are also occurring simultaneously. One mean of improving the distribution transport system is information sharing among each unit in this system, also between different and competing road carriers. There is information that has potential to be value adding for the system if it enables other transport units to change their plans according to different circumstances. By collecting route relevant data, such as road quality, weather conditions and traffic density other affected vehicles in the system can be provided with valuable information at the right time. This information can currently all be collected from the available operational data in the vehicle. Weather data can be collected from control units which are used during certain weather circumstances. Windscreen wipers or rain sensors indicate rain and amount of rain, fog lights indicate foggy or poor sighting conditions and a combination of values can calculate the friction of the road to give information of wet or icy roads. Further suggestions are to use the sensors of suspension to identify poor road conditions and use the front radar to calculate traffic density as done partially today in the operational factor analysis. This information can be valuable in order to prepare drivers behind on the upcoming situation or even autonomous vehicles so they can inform the driver to resume control if the conditions are above the autonomous system's capability. Information of occurring thefts and robberies of goods or vehicle can also be used to alert other vehicles in the vicinity and the authorities. The authorities are also a given receiver of road and weather conditions so that they can quickly and effectively take the necessary measures in order to restore normal situation again. Even though this is a farfetched reduction of waste, the theory and Scania operations in mines considers it important to be aware of obstacles of the road beforehand since it improves the possibility of attending to these and cooperating with the manager of road quality so that the road can be of highest quality possible with low costs.

Another sharing of operational data in the execution phase that is important for the distribution system as a whole and especially the customers of transportation is the sharing of estimated time of arrival. This information is most conveniently also combined with a pre-planned transportation route since this will early on inform the customers of the exact arrival of their orders and then updated in real time as the vehicle approaches the destination. Volvo's service Dynafleet offers such a solution to their customers where they are given a special account to access the Dynafleet service and thereby receive information in real time of how close their deliveries are. This information is beneficial to the customers since it will enable their planning to be more accurate and safety stocks can be lowered since there now is reliable information instead. Through some customer interviews it was clear that this function is important and can eliminate much waste that is generated when customers has to call road carriers to identify the location of their goods and the road carriers in turn has to call the drivers to ask of their position.

Furthermore, the monitoring of temperature and humidity in goods is offered by other fleet management systems and considered in important by customers. This function could be used as quality control to prove or disprove temperature breaches along the supply chain. It could also be used to warn drivers or transport planners if the temperature is outside the preferred levels and allow them to quickly attend to the problem. Information concerning the conditions of a transport is also important in other cases, for example when the transported goods is fragile it is valuable for the customers and the driver to receive information from operational data that affects the transported goods. In the case of fragile goods this might be heavy breaking and acceleration or bad road conditions. These measures of control are in agreeance with the behaviour expressed by company C and A where it is important for them to prove their adherence to the requirement posed on them while fulfilling the transport.

Calculating the loaded weight in vehicles is as discussed difficult. However, one application of weight calculated from the vehicle operational data is possible in the execution phase. Even though there is information of weight and volume in the order information and each vehicle is optimally planned with regards to its capability restraints, in some cases, goods might exceed the previously informed weight and allow the vehicle become too heavily loaded. From a legal and maintenance perspective, it is unsuitable to exceed the maximum load since this causes unnecessary wear to the vehicle and is a risk to others. If the operational data could be used to calculate an estimation of the loaded weight in real time this would complement to order information in the planning stage by ensuring that the vehicle is never above its load capacity. Furthermore, this estimation could in theory also be used to adjust the price of transportation if the weight is more than ordered and allow the road carrier to charge each customer accurately.

During the visits at two road carriers it was discovered that the measuring of trailers is manually executed and often is incorrect or disregarded. However, since the height of a trailer merely is the summation of different operational variables influencing the height, in theory the settings of the vehicle height, the level of the fifth wheel and trailer height should give an estimation of the height enough to issue a warning if the height needs to be control measured manually. Perhaps even a separate more accurate instrument can be added which measures the height from the trailer to the ground. This automatization could simplify the process for the drivers by removing the wasteful procedure of measuring the height of a vehicle every time. Another minor aspect of vehicle height is tyre pressure, which of course should also be added in the equation for vehicle height. However, tyre pressure is another operational variable that has been expressed needs for in research projects and also is available from other service providers. Information of tyre pressure is interesting from a fuel consumption perspective since it influences the friction and thereby the energy required for propulsion which means that if the driver is aware of the tyre pressure he or she can also easily improve the fuel consumption by filling the tires to the recommended level.

5.3 EVALUATING

Despite the availability and use of tools to increase the utilisation in planning and handling of deviations, value for a road carrier can also be found in an understanding of how the operations are performing. Evaluating the performance is important since it gives an understanding of the current state of operations and enables identification of where the improvement potential is. Currently Scania offers performance reports dependent mainly on the fuel consumption, which in turn is affected by driver behaviour. There are also further measurements such as accumulated distance driven per vehicle. However, this information does for example not reveal how well the effective total distance driven has been executed, neither how the fleet as a whole has been performing.

The set of operational data available from Scania connected vehicles contain parameters which could help road carriers understand and improve their operations. Much of the improvement can be found in changing the perspective from the currently driver focused evaluation into a broader perspective of the entire transport operation. By merely increasing the perspective of what are cost drivers in an operation new improvement opportunities appear. In the case of fuel consumption for example, becomes apparent that not only the driver behaviour influences the costs of operations but also the planning operations. Widening the measuring horizon to include planning and execution can aid in understanding how well a company is performing and where to concentrate the improvement focus. Thus, measuring the entire process on factors such as fuel consumption, fill rate and time utilisation could also provide a foundation for further improvements. After all, operational data does not have to be limited to the vehicle operations but preferably include the other operations in a road carrier business. Broader measurements can incentivise transport planners to consider the most optimal route and resource allocation through order management planning but also a higher utilisation of vehicles.

Difficulties of performance measurements is the understanding of what is meaningful for the customers. Despite only considering distribution transportation, there are a wide variation of preferences between different transported goods and different road carriers. For example, when the road carrier is not the planner of the operations, but rather the provider of the vehicle and the driver, the definition of meaningful information changes. It becomes more important for the tier-two customer to receive information whether the transport they have ordered is in adherence with the demands they have specified on the transport such as compliance with road safety legislation or driver working hours. An example of this emerged in the interview with Company C that operates based on pre-planned operations for their vehicles for certain companies. Company C was in those situations only an owner and operator of vehicle whilst the planning and administration was performed by their customer. Consequently, in those situations a company is mainly interested in measuring performance related to the demands posed by their customer and any further performance measuring is of secondary priority. This is an interesting question for the service provider of a fleet management system; who is the customer and how can the services be adapted to this specific customer? The possibility that a tier-two customer of a vehicle manufacturer product could be a tier-one customer in a fleet management system is important to manage.

Understanding what is meaningful is, due to the differences between road carriers therefore not entirely possible, however there are certain performance measurements that have a higher likelihood to be universally useful mainly due to their simplicity. Currently it is possible to access the odometer reading of accumulated distance driven per vehicle but the information is not sufficiently detailed and comparable between different days of operations. If the vehicle distance was both compiled for all vehicles and distributed over days and weeks it would act as an informative performance measurement. A measure which provide meaningful information of the distance travelled with all vehicles is important, because it can be compared to gain an understanding of the differences in performance between vehicles over a period of time. One such meaningful information is achieved by defining measures of cost. It can be calculated from the distance and traveling time and broken down to each trip of road carrier operations. Other performance measurements such as accumulated non-utilised time and technical downtime could also be compiled in order to gain a better understanding of the fleet as a whole.

Order information provides knowledge of the price paid by the customer for a trip which can be used together with the cost incurred by the transport to calculate the profit for each order and unique trips. However, the profit of road carriers is sensitive information and interferes with the core of road carrier management, although the more reason for Scania to provide meaningful insights into this area in order to facilitate decision making. Another useful performance measure is the fill rate in vehicles which can give meaningful insights as to how the different operations are running. Several actors on the fleet management market are already offering fill rate values to their customers through different means, and the customers appear to value this information. Furthermore, the travelled distance can be combined with accumulated weight in order to understand how effectively the distance has been used to transport goods. Similar distances with completely empty vehicles is a possible performance measurement since it is a categorical waste and thereby according to the theory important to manage. Even though there always will be situations where empty transports are necessary the accumulated total transported distance with no load should always try to be minimised. The different means of acquiring order information, highlighted the opportunity to use the current technology to give an estimate of the transported weight. However, this mean of acquiring the information might not suffice to all applications of performance measuring. Although, using operational data to estimate order weight is still usable for calculating the travelled distance without goods.

A further evaluation area that becomes available with the order information combined is the measuring and compilation of deviations from the planned route, as any deviation in theory is an unnecessary movement and should be prevented in an efficient operation. The difference compared with attending to deviations in the execution phase is that there also is necessary to receive information of the accumulated amount of deviations in order to work proactively with preventing deviation from the plan. Even without the order information and thereby not the functionality to plan ahead of operations, route optimisation can still be used to evaluate the performance of the planners and drivers efforts in retrospect during a given time period. This is done by comparing the actual planning with the theoretical optimum, which gives insights into the efficiency of the process and how it has changed over time. However, since not all required information for a complete route optimisation is available, the mathematical model can never really match the reality and it is therefore not possible for manual transport planning to achieve similar performance as the theoretical. That however, does not make a comparison irrelevant since it still might be important with the historical comparison and how the performance of the manual planning has changed over time.

From one customer, it was revealed that the knowledge of trailer utilisation was poor. They claimed that there was no real performance measuring of the usage of the trailers compared to the measuring of usage of the tractor units. Even though this problem is more frequent on long distance freight it illustrates the usage of operational data. Each tractor unit has a connection to external body builders or trailers that forwards information of indicator activity or breaking lights. The knowledge of this connection can be used to gather data of the trailer utilisation. The trailers usage can in theory be mapped in time and distance by measuring the time that a trailer is connected and adding the tractor units GPS position to the trailer when it is disconnected in order to receive a position of each trailer. Although this is achievable under the assumption that all trailers are uniquely identifiable through an electrical contact with the tractor unit, if all trailers are identical this is not possible. If implemented this would give information of the trailer accumulated usage which can be used in the tactical planning of how many trailers should be utilised for operations. Another solution to this problem is to equip all trailers with an RTC unit, in which case there would be no need to analyse the connection with each tractor unit. It would also open for further opportunities of trailer tracking, but consume larger volumes of data capacity.

The environmental effect is an important aspect of road carrier operations. Currently Scania is estimating the environmental emissions of CO_2 and NO_X in their fleet management portal based on the fuel consumption. However, there are sensors for detecting the actual NO_X values and particles, which if possible to implement could be used instead of an estimation. In the future, it is also speculated that the Euro 7 will contain requirements of CO_2 emission limitations (Noble, 2016). Which means that this will likely also be measured and should then as well be included in the operational data that is conveyed to the customers. This information is perhaps not the most important for the flow and efficiency of the transport operations of a road carrier. However, it is becoming increasingly important with detailed reporting of emissions of environmental pollutants and therefore it is of value to the customers to be aware of their exact emissions for reporting purposes.

With increasing urbanisation, there are cases of transport purchasers which are interested in measuring if the contracted road carrier follows the regulations. For example in urban areas noise disturbances is a problem and deliveries may in certain cases not cause to much disturbance. There is not any apparent operational data that has information of how loudly a delivery has been made, however this can be solved through two means of action. First, all applications that emit sound above the regulation, such as engine or the horn, can send an alert when they have been active in a restricted area, thus emitting sounds. Furthermore, each vehicle can be equipped with a decibel meter that can record and alert if the transports are not done to satisfaction. The decibel meter or a sound recorder can also be used for remote diagnostics where an actual audio stream can provide information of the vehicle status to a mechanic. However, this is not something any customer or research project has brought forward and the usage might not be motivated.

5.3.1 Transport Activities

Lead time is an important improvement area in the aspiration for efficient operations. Minimising the time required from the demand arises until it is satisfied free up resources and increases turnover. If the order information is available to the vehicle manufacturer then the information of when the order is entered and when the order is completed is also available and therefore enables a measurement of lead time. Displaying this information for customers will give valuable knowledge of how fast and reactive they are to a customer demand. Exploring the potential of lead time measuring further, the possibility to follow an order to completion in detail would display bottlenecks in the operations. The time consumed by different activities becomes visible and possible for managers to tend to. Identifying and analysing operations on a more detailed level with activities is currently a reoccurring deficit for supply chains as a whole, and road carriers in specific compared with for example industrial production processes. Furthermore, the mapping of activities and identifying value adding and non-value adding are tools in Lean operations, since these can then be either improved or removed in order to improve performance.

An important need for road carriers in evaluating their operations is therefore to identify the activities by which value is created and to then streamline those activities in order to achieve flow. Simplified main activities in a transport operation is planning, loading/unloading and transporting as illustrated by Figure 5. The transport operations are assumed dynamic and different from day to day. However, despite being dynamic they can nevertheless be plotted on a map and analysed for efficiency in the execution of a transport according to the performance measures previously suggested. The theories also suggest means to handle dynamic transport operations. The key is to analyse the cluster of travelled trips for similarities, in other words repetitive trips. If identified, similar trips can be used to establish a current state of operation or a levelled flow with a set pace. A state from which operational improvements can be done. In a true dynamic process, there is however not possible to find a trip that have the same conditions as the weight of the goods, the differences in vehicle, weather, external traffic and other factors also influences each trip and makes them difficult to calculate and compare exactly. However, it will still be possible to find similar trips for which performance can be compared in order to understand how well each trip have been executed. For example, during a set distance of any road stretch it is possible to evaluate and compare different driver performances for that set distance. However, if the wind direction, weather, temperature and vehicle type and goods needs to be the same the comparison is more difficult to perform. With a simplification, this is possible and then in the event of deviation from the current state, it can be analysed why and how and compared with the best driven stretch in order to ensure the deviation does not occur again.

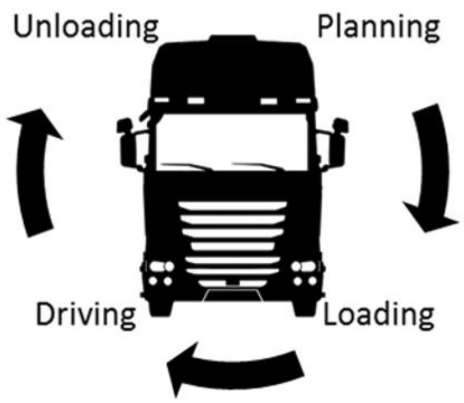

Figure 5 – Activities surrounding a transport operation.

Stopping is an example of when value is prevented since it delays the process of delivering goods to a customer. If transports are evaluated similarly to the operational factors that Scania has developed to assess the context which a vehicle operates within, an interesting mode according to Lean theory is the category *stop frequency.* Analysing the stop frequency gives information of how fluid the transport has been, which is similar to the importance of achieving flow in Lean production. However, clearly a low amount of stops is not achievable in most contexts, due to deliveries in rush hours or down town with many traffic lights as examples. Although, that does not mean it cannot be the goal of operations, to minimize unnecessary stops whilst on route. If this is a performance measure transport planner need to consider time of the day and route in order to plan the route that require the lowest stop frequency. Although this must be put in relation to detours and deviations from a route which are also a waste and needs to be considered together with a stop frequency measurement in order to create the most optimal evaluation system. Alone the measuring of stop frequency might therefore not incentivise improvements, but regarded in the larger picture it should contribute to a better flow in the planning and execution of a transport.

However, the current mapping of activities surrounding the loading activities is not as detailed. The tachograph, which is a legal requirement, informs of when the vehicle is not in motion but cannot differentiate between a driver pause, loading activities or maintenance on the vehicle. The customer interviews indicated the need for a better image of what is being done around the vehicle so that employees are measured more accurately what they are doing in order to align the incentives correctly and prevent the opposite effect where maintenance is avoided because it leads to a false lower utilisation value.

Consider the engine management system, in which there is a function to run the engine but not to use the output energy for propulsion, this is called Power take-off. When this function is activated this means that the vehicle is using any of the tools it is equipped with in order to perform its designated tasks, for example hydraulic lifts, cranes and pumps. Also consider the body work electrical system which manages any external connection with the cab of the vehicle and therefore can give information of which external applications are active in the body of the vehicle. Together with the door management system, these control units can therefore create an image of what the driver is doing during times when the vehicle is stationary. Exemplified for a distribution vehicle this might be opening the driver door to exit the vehicle and then activating the loading ramp. The time between the initial activation of the loading ramp until the final activation of the loading ramp during one stationary stop where the load also can be concluded to have decreased will reveal the time the driver needed in order to unload the goods to a certain customer. Similarly, this could be used for a hydraulic crane in order to measure how much time of a stop is actually used for value adding activities and how much is pauses or unnecessary activities. This application of operational data can be expanded further depending on the specific business of the customer and matching that with the different function of a vehicle activated at certain times.

A further example, is combining the fuel level meter with stops to receive knowledge of refuelling stops and how much time this takes. Overall this could give customers information of the performance of their loading processes and enables them working towards continuous improvements. That knowledge enables the identification of when a loading process for example contain deviations or not. Currently drivers are used to high autonomy of work and are also not very eager in keeping track of which activities they perform and how much time each allocate. Using the information from control units it is possible to circumvent the drivers' reluctance to cooperate in documenting their activities. However, it not always greeted with a positive attitude when starting to study the activities of a driver at all times. The willingness of drivers is important to remember and consider, although within the production industry there has also been similar opposition to documentation of all activities, but has led to large efficiency improvements in the industry.

Managing risks of operations is a part of Lean implementation and is done either through deviation reporting which, if managed, will lead to risk avoidance or through preventive inspection and visualisation of operations. In any case there is potential in the operational data to report risks in the operations. This is being done to a certain extent in the current FMP, but in order to achieve an effective and informative usage of error messages their importance should be raised into being considered as deviations. This gives an insight into what the risks of a road carrier operation are and enables proactive work to manage all risks and as such avoiding non-value creating activities. Consider that all error messages were compiled into daily statistics of how many errors were received every day from the entire fleet. This would give knowledge of the repair status and ability to fulfil the demand efficiently. For example, the amount of propulsion related system error messages can be reduced by good maintenance and proactive repairs and the amount of behavioural errors can be managed through driver education or by other means. Most important is that the errors need to be analysed and brought forward as an important performance measuring tool in order to achieve successful operations through continuous improvements. The current error messages should be categorised and compiled per day so that a trend of risky behaviour can be visualised, however there are further opportunities.

The information of indicator usage from the visibility system and the angle of steering together can provide knowledge if there has been a lane shift without indicating a turn first. This behaviour is associated with risks since other vehicles in traffic are dependent on a signal before lane departure and can be managed in order to prevent accidents to happen. This should work when a lane shift has occurred and the indicator was not active, which indicates a risky behaviour from the driver. Another indicator this is long and therefore unnecessary overtakings, which stalls traffic and is an unnecessary use of fuel. This could be registered also using the steering angle sensor function to register a left turn and then a right turn within certain speed intervals and degree of turning. A long overtake could then be identified by the time between the turns and if too long there is potentially an unnecessary overtake and therefore a risky behaviour. There is also a camera mounted to each vehicle used to identify object in front of the vehicle. In order to be able to attend to different risks identified by the error messages, the camera could be used to record specific events in order to enable an analysis of certain error messages in depth. This could be helpful in driver training in order to understand what was wrong in different situations. These indicators of risky behaviour are as mentioned a part of the current version of FMP, but not used actively as a tool for continuous improvements.

5.3.2 BIG DATA EVALUATION

Vehicle manufacturers furthermore have opportunities in utilising the available large amount of connected vehicles and their generated big data. This could be used through benchmarking, a tool vital for continuous improvements since it is required to know how well the current status of a business relates to other in the same business segment. In general, the importance of benchmarking can always be argued for and in principle any performance indicator becomes more interesting with benchmarking. More specifically all the different performance measurements presented in this analysis are potential benchmarking values: Fill rate, travelled distance, cumulative risks, environmental emissions, trailer usage, unloading times or the fuel consumed in certain road stretches. Voluntarily road carriers could additionally input statistics of their operations such as number of drivers per vehicle or number of planner per vehicle and most important what their specific business area is. Then these values can be complied in order to give an average and an anonymised best value for each business area for other road carriers to strive towards. Benchmarking is a complement to stand alone performance measurements and their historical development because it brings in an external perspective which is vital for a competitive business. This fleet management service for road carriers is useful in establishing a business goal for each measurement and to give a picture of how the competition is developing and in order to effectively operate their business. Benchmarking is also a key advantage for an actor with more connected vehicles since it enhances the quality and extent of the benchmarking information.

Another utilisation of big data that fleet management service possesses is the potential of collecting and analysing geographical points based on the operational data received from connected vehicles. If Scania receives of data from all road carriers, this can be validated, compiled and communicated as a heat map to all Scania customers. The difference compared to the execution discussion is that this is compiled data giving authorities and other road carriers the collected information to be used in for example road maintenance planning compared with acute road repairs. By compiling the data, it also becomes valuable for road maintenance authorities. Another issue for road carriers that can be alleviated through big data is security and theft of goods. Accumulated data can be used to point out areas where there is a significant risk of illegal activities and will allow transport planners to change the plan accordingly in order to avoid any mishappenings.

5.4 FURTHER CONSIDERATIONS

Common for all performance measurements is the difficulty in knowing which are relevant for each unique company. In certain cases, companies might want to measure lead time whilst other prefer fill rate dependent of what the overall supply chain and the company holds as important parts of an offering. From the interviews, it is not possible to distinguish any specific preferences. Whatever performance measures that are most suitable for a company, visualising is a necessary concept in Lean production. Visualisation as a concept however, is broad. In the evaluation stage of any operation Lean theory claims that visualisation of the result of the operations is necessary in order to understand what the status of the operations are. SPS uses a manual board closely to where the value is created. This information board visualises the status of certain selected performance measurements. Which measurements that should be chosen are those that are relevant to the overall strategy of the company, once again emphasizing the differences between what is meaningful information for different companies and making it difficult to establish the most optimal set of measurements for a road carrier. LOTS and SSO however, use digital screens when visualising performance. What appears to be reoccurring in both cases and in theory is a careful selection of the most relevant performance measures which should all be displayed together with the historical development and a benchmarking value from the same business area.

If the overall operational performance of the entire operation could be calculated in a similar manner to how driver evaluation at Scania is done today the fleet management system would have more effect. This can be done by compiling different information into a pedagogical grading system where it is clearly evident what needs to be improved in order to reach the next step in the grading system of the transport operations. Such a presentation would enable a simple intuitive measurement of the overall performance of a road carrier business.

The task of a fleet management system is to enable a high reliability, low costs and customer satisfaction of operations through planning and risk management. Achieving this require supportive services in all the phases of operation; planning, execution and evaluation. The most value according to the theory can only be created if all phases of a logistical process are supported. Such a state of operations is in accordance with the Scania life cycle value goal, to lower the overall costs of purchasing a heavy vehicle. Therefore, an efficient fleet management system could be one part in achieving this.

The exact financial costs of different fleet management systems have not been analysed, but it is certain from interviews that Scania FMP is one of the more expensive compared to the other systems on the market. Comparing the functionality is also not to the benefit of FMP since its functionalities are limited to positioning the vehicles on a map with certain statistics of performance and maintenance planning. Systems competing with FMP provide further knowledge of the operations through integrating order information with a map functionality and thereby creates more value to logistical companies. However, when the competition is not from another vehicle manufacturer an external system always requires either some external hardware to be installed or will never quite eliminate the functionality of FMP which means that two or more systems are required. From that aspect, FMP has an advantage in including other services and allow customers to more often make use of FMP primarily since that is what they prefer, to lower the amount of systems required for operations.

Widening the perspective further out from the optimisation of the operations of a single road carrier and consider the problematic situation of an increase in road bound transports which amounts to more than the capability of expanding and improving the road system. From that it is evident that a system wide efficiency improvement is required in order to prevent a capacity breach in the road system. For example, with accessibility to data from connected vehicles, belonging to several different road carriers. There would be an opportunity to decrease system wide costs due to sub optimisation between different competing road carriers. A reason for sub optimisation and intercorporate waste is present could be competitive secrecy and lack of information in the transport market. Resulting in two road carriers operating the same distance with only partially loaded vehicles, since they are not sharing information and are therefore not aware of each other's movement. If this information was shared the two road carriers could transport the goods together and equally share the decreased cost from both sides and a system wide improvement would be reached if these transports were combined. Such an understanding of the inefficiencies of a system is partially available with the current data collected by Scania but would be helped and fully usable if the information of which orders that are being transported was to be acquired. In such case Scania could partially alleviate the system wide transport inefficiency by contributing with transportation data to the road distribution system and therefore enable smarter and more efficient transport solutions.

6 CONCLUSIONS

The transportation system today faces the opportunity and challenges of increased transportation demand and inefficiencies. Heavy vehicle producers have potential to enhance their product portfolio by developing services to aid road carriers in achieving higher efficiency in their operations. Despite an abundance of fleet management services available today for road carriers, original vehicle manufacturers have an opportunity to make usage of the operational information embedded in a vehicles electronic control system. The interviewed small and medium sized road carriers illustrated both ineffective means of planning through manual tools such as Microsoft Excel and more optimal ones, but not sufficient. Common denominators were the utilisation of multiple overlapping systems, a lack of well-developed performance measures and an insufficient and manual communication with the other actors in the supply chain. For an optimal supply chain and optimal usage of the vehicle capacity, a common understanding of what value is and which activities that contributes to that value are important. Also important, is working towards a flow in those activities through continuous improvements of the process. Achieving a well performing supply chain, therefore require a better usage of the operational information to comprehend what influences the performance better. The operational data sent from the connected vehicles can be utilised in three steps in the process of transportation; planning, execution and evaluation.

During the planning of a transportation process, the application of operational data is limited since operational data is generated only when the vehicle is in motion. Still much of the waste accumulated in the transport industry is occurring in the planning phase. This can be relieved if the definition of operational data is expanded from the operational performance of the transporting vehicle to the operational performance of the transport executed. Which can be achieved by including an order management service in the FMS in order to capture the information of what is being transported. The reason knowledge of order information is so beneficial to the improvement of a transport operation is the timeliness of the information. In advance of planning the operations, order information will provide information of weight, volume, time and destination to the system which enables the system to assist in the planning process. With a 5-30% efficiency improvement through optimal allocation of resources and route selection it can provide much value for road distributors. There are also tactic and strategic applications, which will assist the road carriers in sizing their fleet and distributing their warehouses. Therefore, the inclusion of order information is important for a comprehensive fleet management system.

An additional service, that can complement the operations research, using the information of prices and frequency of demand to suggest price changes in periods of low or high demand. This will potentially even out and distribute the usage of drivers and vehicles which will increase the resource utilisation. Also, taking advantage of the big data input of order information, a vehicle manufacturer can also utilise its neutrality to facilitate a marketplace for freight capacity purchasing.

Important considerations in the conceptual inclusion of order information into operational data, is which order information should be included and who should have access to the information. Most purposeful would be to ask customers of road carriers to also include information of the context of the order, by asking why this transport is required and how they wish the order should be executed. This will enable a better congruency throughout the supply chain and prevent counteractive activities. Providing a tier-two customer access to the real-time information of the execution will decrease wasteful manual communication with the road carrier. It will also allow tier-two customers to decrease their buffer storages and to manage any delays instantly thanks to a greater information security.

The execution phase of a transportation assignment is a critical phase revolving around the timely and accurate delivery of transport orders, something which a fleet management system is designed to manage. The fleet management system examined does not provide the management support needed to realise and manage occurrences that might affect the accuracy of deliveries. A useful fleet management system displays and enables real time risk management. It is not sufficient with an error notification for certain errors in the vehicle or when vehicle enters a forbidden area. A requirement that provide value for customers is primarily a visual and comprehensible presentation of the status of the operations. Indicators of status are current error messages but also if order information and a planned route is available, adherence to or deviation from the estimated time of arrival. Further application can be notifications of any deviations from the planned route, current load and potential overloading, goods temperature and disturbances from shakings, supervision of tyre pressure and a detected risk behaviour based on analysis from the operational data. In fact all vehicle operational data should be accessible by a transport planner since it enables the transport planner to manage the execution phase in real time. This will enable them to prevents risks from occurring and thereby eliminating potential waste.

There are more applications outside the usefulness of the transport planner, once again involving the tier-two customers who have posed specific constraints on the operations of the acquired road carrier. Operational data information will ensure the compliance of road carriers. There is also possible to achieve system wide performance improvements from operational data containing road and traffic conditions. This information should be gathered and communicated to other actors that are either responsible for the road maintenance or operating on the road. Vehicle operational data from windscreen wipers and sensors, fog lights, engine load and wheel revolutions and front radar will provide meaningful information of weather and road conditions if communicated outside of the vehicle.

Lastly operational data can improve the evaluation phase of a transport assignment. Seeing as the foundation of continuous improvements is evaluation, this is an important phase in providing a correct image of how the operation is performing. The evaluation should provide comprehensive insights into the performance of selected important areas of the business, areas of business that are aligned with the strategic direction of the company. An important improvement area within evaluation is although the mapping of transport activities through the utilisation of information received from vehicle components used in different activities such as unloading. In general however, a supportive fleet management system should contain all information of fleet performance and have a level of flexibility for the customers to adapt the extent and focus of the evaluation.

7 RECOMMENDATIONS

The improved utilisation of operational data is vital for long term ability of Scania to provide value adding services in a dynamic road distribution system. A higher utilisation can be achieved mainly in the evaluation phase of a transport, which contributes to removing waste from the transportation process as a whole. Despite this, operational data from connected vehicles have a limited potential in providing customers with value. A fleet management system should assist road carriers to manage their resources and orders in all of the transport phases; planning, execution and evaluation. It is therefore important to widen the perspective on fleet management. We recommend Scania to further improve FMP to adhere to these three operational areas in order to make as much use of the operational data as possible. Therefore, the concept of operational data needs to be expanded to include not only in-motion operational data from the vehicle, but also order information to provide the most value for Scania's customers. The advantages of such an expansion is the opportunity to offer a service with value creating support in all necessary phases of a transport operation.

Without the order information, it is not possible for customers to use Scania as a single service provider. Instead FMP must be used as a complementing system which complicates the user experience. If Scania would use order information and combine this with a route optimisation feature available for Scania customers, this would generate value for their customers. However, it is not sufficient to expand the fleet management perspective into the three phases of transportation. It is also valuable to consider a historical and a comparing perspective, instead of the current driver focused perspective. Implementing a historical perspective for each performance measurement in a fleet management system is combining both utilisation of operational data and customer value. Additionally, Scania has an advantage in having access to a large amount of performance data from different road carriers and business areas. We recommend the usage of this data to provide benchmarking reference to road carriers in their evaluation. If refined through analysis Scania can give meaningful comparative data to their customers. Each performance measure in the evaluation stage should therefore be complemented with a historical and competitive value in order for road carriers to understand their performance in a large perspective.

Currently FMP is not used as a fleet management system by customers, it is rather used as a fleet positioning system. The majority of usage is the positioning function which provides questionable value to the customer. Meaningful information is instead knowledge of when a vehicle is deviating from the plan. Additionally, a potential market expansion for Scania is making their information available to tier-two customers which further complicates making one service that suits all. Therefore, we recommend Scania to offer an adaptable fleet management system where it is possible for customers to decide themselves what to measure and visualise in FMP. Some examples of KPIs that we believe would be useful for customers to show in FMP are listed below:

Disturbed goods – Counts the amount of exceeded levels of disturbances to the transported goods.
Distance Trailer – Accumulates the total distance driven with a trailer attached.
Delays – Counts and or accumulates delayed orders.
Driving without Seatbelt – Accumulates the distance driven without seatbelt.
Empty rate – Accumulates the amount of empty driving by the fleet.
Environmental emissions – Using the NO_X sensors to give exact estimation of environmental emission
Error messages – Accumulated amount of error messages.

Fill Rate – Measures the utilisation of vehicles by measuring how full vehicles are on average.
Flow – The number of accumulated stops for certain orders or time periods.
Kilograms Delivered – Accumulates the total weight that is delivered.
Lead Time – Measures how long it takes from an order is received until the order is delivered.
Load Time – Measures the average loading time.
Orders Delivered – Counts the total number of delivered orders by the fleet.
Overtakes without using Indicator – Counts the turns when indicators are not activated.
Pallets Delivered – Counts the total amount of delivered pallets by the fleet.
Planning Efficiency – Comparing the manual planning with the theoretical optimum in hindsight.
Sound Emissions – Number of sound emission events exceeding the current limit.
Technical Uptime/Downtime – Accumulates the total time a vehicle or fleet is functioning.
Traffic Incidents – Counts traffic incidents were customer's vehicles are involved**.**
Wrong Turns – Counts the total number of wrong turns.

Scania has all prerequisites to provide a valuable service. Scania controls and has access to more in depth operational data compared to products by other third-party business. Scania also has the advantage that the service being attached and included with a product. However, some of the competing companies which provide FMS consists of a few employees and are still able to offer more valuable services than Scania is offering with FMP. There is therefore potential for Scania to improve your services. Especially since smaller road carriers do not have the competence or the resources necessary to develop their own service as larger road carriers do. Therefore, Scania has a large market potential in providing a complete fleet management system and bridging the gap.

According to us, FMP is currently not a competitive fleet management system. It is missing necessary and basic features. We recommend that Scania should develop FMP to a single system so that third party fleet management systems does not have to be used by Scania customers. This is also of importance for the future since the operational and order data is valuable for Scania and the service of the transportation solutions will become increasingly important in the future. Scania has the potential gaining market shares today when the FMS market has yet to grow to its full potential. But when the distribution is managed more and more autonomously a FMS will become more important and develop towards a core offering, perhaps even more important than the vehicle itself. FMP is conclusively currently an important service with large potential of creating value for Scania customers if complemented with order information and a widened perspective on what creates value for the customer.

8 DISCUSSION

Using a case study approach, we have considered new utilisation areas of connected vehicle operational data from a logistical point of view. We have taken inspiration from ground theory in Lean theory and fleet management and combined this with practical implementation knowledge of Lean. This have been applied to supply chain management and transport operations in order to understand where operational data can be beneficial. The objective of this research was to identify possible value adding service concepts, which can be developed based on connected vehicle operational data. This have been done by addressing the following research questions; *(1) What are the current Scania transportation services, both available and under development? (2) What does the operational data consist of and how is it generated? (3) How can these services be improved using operational data and/or new sources of information?*

Scania's transportation service portfolio is extensive, which have limited our ability to include all parts and thus not managed to form a complete picture of all services. Partially because we have not been introduced to projects in time for the thesis. Also, since the data collection was made from a snowball sampling method, it was crucial that the interviewees understood the purpose of our research in order to enlighten us of relevant projects. It required that we were able to explain what type of information and projects that were of interest to us, which in the beginning when most interviews were conducted was not always possible. For an improved understanding more attention should have been at explaining the purpose of our thesis and asking for more projects that might had been of interest to us.

We are however satisfied in the efforts made to gain an understanding of operational data. Despite the electrical system of Scania's vehicles is complex and extensive we managed to gain a basic understanding of all the different components of the systems, enough to understand which unit that could contain information of value for the objective. However, with a deeper understanding of each measured variable there would certainly be some further possibilities of service concepts and recommendations. Also, we encountered an ambivalence in the definitions of different operational data concepts and what was actually included in each subset of operational data. It seemed as if different groups within Scania had different definitions or was only specialised on their subset. But we believe we have managed to gain an understanding of the concept satisfactory for this research since we have gained elemental understanding of the different electronic control units and how the data is generated.

We have focused our recommendation on the improvement and growth of one of Scania's services. This is not entirely in accordance with the question, however instead of improving each different service we have suggested a combination of services in order to better fulfil customer requirements of one service. Furthermore, this question can of course not be answered completely but has been restricted by both time and knowledge. A narrower question might have been favourable, but we have managed to recommend both possible improvements to services and new sources of information that we believe can generate value according to the research objective.

8.1 THEORETICAL CONTRIBUTION

The identified gap in the research bridges between theoretical applications of Lean into production and practical knowledge from Scania concerning Lean implementation into fenced off mining operations and improvements in dynamic road distributions systems. Our conclusions therefore contribute to how the knowledge of how Lean can be applied on a dynamic road distribution system.

8.2 FUTURE RESEARCH

Our findings of the potential in operational data are new to the area of fleet management. However, we were required due to a time limit to not consider the potential of our different findings. An important further research is also to give an estimate of the actual waste saving potential of the different findings. Each service concept could be researched further and evaluated according to its potential to reduce waste, either qualitatively through customer centred analysis or quantitatively through computational modelling. Furthermore, we initiated a very interesting area of interviewing fleet managers of their experience with different fleet management systems and their challenges and opportunities related to that. We also did not consider interviewing tier-two customers of their experience and need of fleet management systems, something we consider an important research area. The restriction on time forced the research to limit the market analysis on other vehicle manufactures and third-party service providers. However, there are several extensive market analyses which convers that area which renders that research area less significant. Lastly, we believe it would be interesting to conduct research how Scania's FMP should be developed to enable customers to use it as a single FMS service.

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10 APPENDIX

Interview guide for Scania employees within Research and Development

Background

- Name
- Position/title
- Responsibility
- History at Scania?

Service development

- How and in which form are you contributing to increased transportation service development at Scania?
    - Any projects?
- What is the purpose of any project(s) or your work and by which means is it acheived?
    - How does it create value for the customer?
    - Elaborate a bit over the development of each project until today, what has lead up to the current situation/position?
    - What specific operational data is the project utilising currently?
- What is the future development plan for the project(s)?
    - How will that further increase value for the customer?
    - What challanges are associated with this?
    - Which specific operational data will be required by this in the future?
        - Is it avaliable or not?

Ending

- Are you aware of any other value adding transportation service projects at Scania that we might find useful?
    - Any project using operational data?

Interview guide for Scania employees within Vehicle and Maintenance sales

Background

- Name
- Position/title

Daily operations

- Which tools does Scania customers use in their vehicles? Scania and external?
- How do they communicate with their drivers?
- What are common challanges in their daily operations?
    - Are there any thing the customers need today that you know could improve their operation? Information, service?
- How does the customers measure efficiency? Which KPI? Driver/vehicle/trailer utlization? Fill rate? Customer satisfaction? Operational/technical uptime?
- What are Scania customers not satisfied with? dissatisfaction?

Interview guide for road carriers:

Background

- Name
- Position/title
- Responsibility

About the company of the interviewee

- Name
- Size of operations
    - Fleet
        - How big?
        - What vehicles? Why?
    - Drivers
        - How many?
        - Any training?
        - Trustlevel?
    - Planners
    - Turnover
- Market focus, differentiation? What is your niche?
- What is your typical workorder?

Daily operations

- How many unique orders do you handle daily on average?
- How do you plan the different levels? (Strategic, tactic, operational)
- How do you plan the operation of these orders?
    - Could you lead us through the process? From order received to delivery?
    - Which tools do you use?
    - How many personel-hours are utilized for this process?
    - How do you manage changes of a plan?
- How do you communicate with your drivers?
- What are your current challanges with the daily operations?
    - Are there any thing you need today that you know could improve your operation? Information, service?
- How are you aware if you are performing your transportations efficently? How do you measure efficency?
    - Which KPI? Driver/vehicle/trailer utlization? Fill rate? Customer satisfaction? Operational/technical uptime?
- How do you measure and manage customer dissatisfaction?

Focus group questions

- What do you think will be the customers of Scania’s demand for services today and in the future?
- How do you think operational data can be used to accommodate these demands entirely or partially?