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An investigative case study of implementing a Transport Management System (TMS) with a rail freight network

Master's thesis in Supply Chain Management

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An investigative case study of implementing a Transport Management System (TMS) with a rail freight network

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Abstract

This thesis examines the organizational prerequisites for implementing a Transport Management System (TMS) within Volvo Cars inbound logistics rail freight network. Volvo Cars is the largest automotive manufacturer in Sweden and their inbound logistics operations handles hundreds of transports each day. By analyzing the case presented by Volvo Cars the study aims to provide answers to the following research questions: What actors, resources and activities are included in the rail freight network of this study? What information attributes are necessary for a successful TMS implementation of the rail freight network? What potential effects would a successful TMS implementation have on the rail freight network?

The research provides a detailed map of all actors, resources and activities involved in the network as well as, a description of the rail freight process studied. The findings reveal that the centralized rail freight network studied is highly complex, primarily due to the number of actors involved and the facts that multiple systems that needs to be integrated to allow efficient communication. In addition to this, the structure of the network further contributes to the complexity of implementing a TMS since it demands a high degree of flexibility from the system.

Through comprehensive analysis of the process, the critical information attributes for a successful implementation was identified and presented as well as additional information attributes that contribute value to the process but with less critical impact. Furthermore, the findings indicate numerous potential effects resulting from a successful implementation of the TMS. From the operational perspective, using a TMS would decrease the human errors and miss understandings due to inconsistent communication as well as, increase the pace of decision-making in time sensitive situations. From the strategic perspective the generation of more data would lead to increased possibilities of improving and optimizing the process and provide a better general understanding of the rail freight network. The experience of implementing the TMS it would also benefit future rail freight initiatives of Volvo Cars.

Keywords: Transport management, rail freight, transport management system, system implementation, information attributes, information exchange

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1 Introduction

The topic of this report is to investigate the organizational prerequisites required for a successful implementation of Volvo Cars' rail freight transportation routes with their existing Transport Management System (TMS). This section will cover the background of this case study and the important aspects of why this study is relevant. Furthermore, the problem will be defined and described along with the aim of the thesis. Lastly, research questions will be developed and limitations of the thesis will be stated.

1.1 Background

Every year there are billions of tons of goods transported across the globe (Greene, 2023), many of which are components and/or materials for various industries. The logistics for the transportation of goods are divided into two types, inbound and outbound logistics, where inbound is concerned with the supply-side and outbound is focused towards the distribution-side. Inbound logistics could be defined as "the flow of materials and information, from the source of raw materials to the entrance at the factory" (Antonio Mitsumasa and Jandecy, 2017), meaning that all cargo transported from a supplier to a company is part of inbound logistics. To transport this exceptional amount of cargo across the world, several transportation modes are used. According to Lumsden (2007), the four primary modes of transportation include sea, air, rail and road, where the majority of cargo is transported by sea (International Transport Forum, 2021). However, road transportation accounts for 65% of total freight emissions (International Transport Forum, 2021), which is a huge environmental concern. Based on a report from the International Transport Forum (2018) the road transportation sector is rapidly growing and Eurostat (2022) show that in the past decade over 70% of inland transportation in EU consisted of road transportation, peaking at 77.4% in 2020 (Eurostat, 2022). Given its negative environmental impact, a more sustainable means of transportation is required. Many suggest rail freight as a viable and more sustainable option (European Court Of Auditors, 2016; Roso, 2007; Alessandrini et al., 2012) and the European Union has a target of doubling the transportation share for rail freight by 2030 (Rail Freight Forward, 2020). The European Environment Agency (2022) show that rail freight has the lowest level of emissions for freight transportation and is therefore an appropriate candidate in the efforts of reducing the overall emissions caused by the transportation sector. However, most companies still choose road over rail freight.

Dionori et al. (2015) states how it is the shipper (the firm requesting the shipment) rather than the carrier (the actor transporting the shipment) who control the transportation modal choice. Many shippers are concerned with reliability and on time-delivery (rather than the cost of transportation), which favours road transportation (Dionori et al., 2015). Additionally, there is a strong bias against using rail freight (Patterson et al., 2008). Hegedus et al. (2018) found that a lack of technological advancements and a high amount of stakeholders involved made rail transportation inflexible, while Amos (2009) suggests that the information flow in

rail freight is insufficient. It is therefore evident that the rail freight sector needs upgrading in order to compete with the current favourite, road freight. Amos (2009) describes how Indian railways upgraded their infrastructure and information systems, which resulted in improved equipment utilization among other advantages. Similarly, Amos (2009) states how computerization and centralization of information has led to overall improvements in rail freight. With this said, Wiegman et al. (2007) claim that innovation in the rail transportation sector historically has mostly affected the rail terminals, emphasizing that future innovation must improve the rail freight sector in its entirety.

From the supply chain management perspective, the management of freight transportation is paramount in order to have a well functioning supply chain. Coyle et al. (2015) describes efficient transportation systems not only as a mean to grow the business but as a competitive advantage for the organization. In order to manage large networks of logistical services, organization usually implement a Transport Management System (TMS). According to Rutner and Gibson (2002) the function of a TMS is to increase the visibility of transportation data across logistical networks and can greatly increase the performance of a firms logistical operations, mainly from increasing the information flow between actors involved. Similarly, Kalaiarasan et al. (2022) discuss how increased visibility in the supply chain enhance operational activities and improve information accuracy, accessibility and timeliness. Kalaiarasan et al. (2022) also emphasize how technological advancements are crucial in order to improve organizational visibility which strengthens the argument to invest in the implementation of a TMS.

1.2 Company background

This thesis is based on a case study conducted with Volvo Cars in regards to management of their freight transportation for inbound logistics. Volvo Cars is a large automotive vehicle manufacturer founded in 1927 in Gothenburg, Sweden (Volvo Car Group, 2020). Volvo Cars has since developed into a global organization with manufacturing facilities in multiple continents across the globe. Due to the global presence of Volvo Cars they have developed a vast network of partners when it comes to their inbound logistical services (Volvo Car Group, 2020). Today Volvo Cars has a broad network of road, rail, sea and air hauliers for inbound logistical freight transportation. This network is managed by the supply chain management department of Volvo Cars in order to maximize the value from all their partners and services.

According to Volvo Cars, they currently manages their transportation in different systems depending on what modes are involved. For example, their road transportation are managed within their TMS whilst their rail transportation are not included in this system and are mostly managed through manual communication channels such as emails and excel reports.

1.3 Problem discussion

As mentioned in Section 1.1 the need of advanced TMS is of great importance for organizations with large freight transportation networks. However, Volvo Cars has had issues when trying to introduce their train transportation mode with their existing TMS. Due to the number of stakeholders involved in transporting goods by rail, the task of successfully implementing the rail freight route into a existing TMS becomes complex (Hegedus et al., 2018). Furthermore, especially large organizations struggle in adapting to change due to large organizational inertia (Boyer and Robert, 2006), which can result in the introduction of new transportation modes does not become integrated into the existing TMS of the organization.

To enable the integration of rail freight transportation into a TMS there are numerous actors, activities and resources that needs to be aligned. As the study conducted by Luisa dos Santos Vieira et al. (2013) shows there are several important aspects to consider regarding the perspective of the Logistical Service Provider (LSP) in order for the Information Communication Technology (ICT) to operate efficiently. Therefore, to successfully implement such a system all actors, resources and activities must be accounted for. Furthermore, Jacobsson et al. (2017) suggests that a successful implementation needs to analyze the different information attributes shared between the actors involved. Understanding the characteristics of the necessary information attributes and how these attributes affect the actors involved is crucial in order to successfully implement a rail freight route into an existing TMS.

In Volvo Cars current situation there are several important attributes that they are unable to efficiently track when it comes to their rail transportation for inbound logistics. The issue in question concerns their freight train transportation from a components production plant, named Plant C to the assembly sites in Plant A and Plant B (see section 4.1.2 for a detailed explanation of these plants). The two transportation routes of the rail freight network are not included in Volvo Cars' TMS, which limits the visibility of information and the real time update of data as information is currently exchanged manually through e.g. email and telephone calls. According to a Volvo Cars Manager, this manual process of handling data regarding the train transportation creates issues when it comes to reporting statistics on transportation quality such as delivery deviations, correct delivery items, defect items delivered etc. Therefore, including the train transportation in the existing TMS would benefit the inbound logistics transportation operations both by reducing time spent on generating data but also increasing visibility of the transportation status through real time updates.

Jacobsson (2020) has published a paper which explores access management, including the benefits of efficient communication between actors involved in intermodal transportation activities at a given terminal. Meanwhile Luisa dos Santos Vieira et al. (2013) describes the importance of the implementation process of ICT and how to manage it correctly whereas Santos and Piva (2021) present a case of an implementation of a TMS in the automotive industry, highlighting key aspects and

the improvements the TMS provided. Even though Santos and Piva (2021) present a case in a similar field as this thesis, the article focus on the implementation of an entire TMS in a context where it did not previously exist, which deviates from the aim of this report. Horvath (2020) discuss how accurate data improves transportation efficiency while Hegedus et al. (2018) explain why rail transportations are more difficult to track and trace. All the mentioned papers and article discuss relevant points regarding communication, IT-systems, rail transportations and their relation. However, through extensive research, no paper was found investigating the organizational prerequisites to successfully implement a rail freight transportation route with an existing TMS of a private company. In this case, organizational prerequisites refer to internal and external factors surrounding a company that could affect the implementation of a TMS.

1.4 Purpose & research questions

The purpose of this thesis is therefore to investigate the organizational prerequisites required for a successful implementation of Volvo Cars' rail freight transportation routes with their existing Transport Management System (TMS).

The thesis will be based on a case study at Volvo Cars. To fulfill this purpose, the thesis will map all actors, resources and activities involved in the rail freight operations at Volvo Cars as well as identify and analyze the information attributes needed for a successful implementation with their existing TMS. Furthermore, this thesis will also investigate the potential effects of a successful implementation. By fulfilling this purpose, this thesis will fill the academic gap discussed in Section 1.3. This will provide an insight towards what considerations companies should take when they want to integrate a transportation route with an existing TMS, hopefully helping both researchers and companies in the future.

Based on the purpose discussed above, the following research questions were developed regarding the rail freight network at Volvo Cars:

- **RQ1:** *What actors, resources and activities are included in the rail freight network?*
- **RQ2:** *What information attributes are necessary for a successful TMS implementation of the rail freight network?*
- **RQ3:** *What potential effects would a successful TMS implementation have on the rail freight network?*

1.5 Limitations

Given that this thesis will be based on the case study of Volvo Cars rail freight transportation from Plant C to Plant B and Plant A, the findings of this thesis might be exclusive for Volvo Cars and the automotive industry. The thesis will not

investigate international differences, for example transport- regulations, standards or other compliance areas that might differ from the specific case of this study. Furthermore, the thesis will be dependent on the existing TMS of Volvo Cars and the information that Volvo Cars and other involved stakeholders disclose limiting the study from investigating other TMS solutions that might be relevant. The findings of this paper will not include the actual implementation, but rather provide a theoretical documentation of what considerations needs to be taken.

2 Frame of reference

The following chapter introduces the frame of reference, which is used to build a foundation for the research conducted of this report as well as provide the reader with a better contextual understanding. It is used to gain further insights regarding rail freight, information systems used in logistics, communication and logistics operations. The frame of reference was developed through relevant literature review.

2.1 Rail freight in the context of inbound logistics

Logistics involve the flow of material and information between organizations or within an organization, where inbound logistics focuses on the flow from the raw material source to the manufacturing company (Antonio Mitsumasa and Jandecy, 2017). Transportation is in turn used to transfer goods between organizations, where rail freight is one of four primary transportation modal choices. During rail freight, a locomotive, which could either be diesel or electric, pulls a number of wagons on a fixed rail infrastructure, making it more limited than the road network. The transportation unit used for most freight wagons are containers. The benefit of using containers is that they usually have standardized dimension based on ISO, which allows them to easily be transferred between different transportation modes (Lumsden, 2007). For any transportation made, there is a legal requirement to have a bill of lading, which is a document that contains information about the transportation (Beecher, 2006).

A common method of rail freight used by manufacturing companies is full train transportation. This method involves filling an entire train and directly transporting the goods from one sender to one receiver, without loading or unloading in between. This requires large flows to be justified but results in a reduced transportation duration and a higher level of cost efficiency (Lumsden, 2007).

2.1.1 The benefits of using rail freight

According to United States Environmental Protection Agency (2022), CO₂ emissions accounts for the majority of Greenhouse gas (GHG) emissions in the transportation sector. The main benefit of using rail freight is the significantly lower CO₂ impact compared to road freight. Based on data from 2013, rail freight generates seven times less GHG emissions compared to road freight (Protopapas et al., 2013), making it significantly more energy efficient. To align with the Paris Agreement (United Nations, 2015), GHG emissions need to be significantly reduced, which is why The European Union has set a target of doubling the share of rail freight by 2030 (Rail Freight Forward, 2020) and to further increase its share to 50% of total freight modes used by 2050 (Poliński and Ochociński, 2022). On top of its environmental benefits, both Hellner (1999) and Balog et al. (2019) mention how rail freight is a safer means of transportation in terms of less accidents, which aligns with Poliński and Ochociński (2022) view of rail freight reducing road congestion and removing hazardous cargo from the roads. However, Ones and Dilchert (2012) discuss the importance of educating workers throughout the organization in order

to value sustainability in order value sustainable options besides the costs and efficiency, otherwise environmental sustainable solutions will be overthrown by more efficient or cost-reducing solutions. Other advantages, as highlighted by Balog et al. (2019) include high load capacity, cost efficiency and the capability of transporting light as well as bulky cargo.

Even though the undeniable benefits that rail freight provide, customers have been losing confidence in the rail freight sector (Poliński and Ochociński, 2022) where the European rail freight industry has been at a decline for over seven decades (Chapuis et al., 2022).

2.1.2 The challenges of using rail freight

Hegedus et al. (2018) list several challenges faced by the rail freight sector. Among these challenges include how rail freight still operate according to traditional methods due to the difficulties of introducing change and innovation. Hegedus et al. (2018) explain that due to the characteristics of rail freight, change and innovation require long-term planning, which is further perplexed by the number of stakeholders involved in the process and their need for an inter-operational relationship. Part of the insufficient innovation include a lack technological advancement. Berrios Villalba (2020) address how the rail freight sector is not up to date with the modern state of technology and how basic levels of digitalization has not yet been incorporated, resulting in inefficient maintenance diagnostics and train preparation times. Additionally, Berrios Villalba (2020) emphasize an issue regarding the low amount of digital resources used by employees during rail operations, which according to Berrios Villalba (2020) is mainly caused by the long life-cycles of old and existing systems. Due to long approval and development processes among rail freight actors, it is difficult to quickly incorporate new technologies that emerge. An example of this issue would be, as highlighted by Hegedus et al. (2018), the low levels of track and trace availability among rail operators. Chapuis et al. (2022) discuss that technology to enable track and trace incorporation has existed for many years, but that even though tests are currently being carried out by major railway companies, no standards has yet to be chosen and the technology is expected to still be in the pipeline for several to come. This slow progress is emphasized by an article published over two decades ago by Hellner (1999) who already back then pointed out how railway companies in Europe were unable to agree upon standardization and which technology to use for tracking and tracing containers, wagons and locomotives.

Poliński and Ochociński (2022) similarly stress the need for advanced technology in the rail freight sector, but also how inadequate laws and a lack of competence among decision-makers fuel the decline of rail transportation. As discussed by Amos, 2009, while much of the rail freight industry is privately-owned, the rail network itself is commonly government-owned. In Sweden, almost 90% of the rail network is owned by the government as of 2021 (Trafikanalys, 2022. According to Amos (2009), this causes private actors within the rail freight sector having to deal with governmental regulation and bureaucracy. For example, since freight and passenger trains usually travel on the same tracks, they are commonly treated by governments

as 'the business of running trains', even though the business structure is significantly different. Given this, politicians usually prioritize passenger train investments and allocation of track capacity, crippling rail freight operations (Amos (2009)). Another major concern arise when transporting goods across international borders. Different regions in Europe and across the globe have a varying rail gauge, meaning that the width of train tracks differ. This forces cargo reloading at certain border-crossings, which is both time-consuming and costly (Szkoda, 2014).

Marinov and Viegas (2011) conducted a simulation showing that high amounts of schedule deviations causes increased queues and less trains served, which is the result of disorganized rail network operations. In contrast, a structured rail network operation will lower queues, and thereby the amount of deviations, which in turn would reduce costs incurred by the companies operating within the sector. With the implementation of more advanced technology, a more structured network could be achieved and thereby improve rail freight overall. This shows that if technology advancements are made, several benefits and improvements will follow.

2.2 Information system involved in inbound logistics

For two decades the surge of new information technology development has had an incredible impact on organizations across the globe. In order to understand the impact of information systems involved in the inbound logistics processes, information and information systems must first be defined. According to Buckland (1991) information can take different shapes and forms depending on whether its tangible or intangible, as well as if the information is a process or a entity. For example, tangible entities of information can be documents, data or recordings whilst an intangible entity of information can be knowledge (Buckland, 1991). In order to utilize the information entities within the organization the information process needs to be facilitated. Information as a process refers to being informed by communicating and sharing data. This contributes to transforming the personal knowledge and stored information into organizational learning which drives continuous improvement within an organization (Buckland, 1991).

One reason why the revolution of information systems is relevant from a logistical perspective is that the nature of logistics often involves multiple different actors included in the same process where cooperation and timing is crucial for efficiency. The complexity of sharing information between multiple actors in real time with precision which is therefore often accomplished with an IT-system (O'brien and Marakas, 2006). On a high level of the organizational hierarchy it is crucial that decision making is based on updated and correct information which requires Management Information Systems (MIS) to transfer information vertically within the organization (O'brien and Marakas, 2006). MIS usually consists of multiple sub systems which paints the bigger picture with the most crucial information elements and with less details than the operational sub-systems. The use of information systems can bring tremendous organizational benefits and competitive advantaged such as visibility of the organization and it supply chain, and reducing tedious man-

ual labor, contributing to greater deviation management, predictive capabilities and resource efficiency (Kalaiarasan et al., 2022; Rainer and Prince, 2021). Visibility is described by Somapa et al. (2018) as information accessibility, accuracy, timeliness and completeness of information within the organization. According to Rainer and Prince (2021) IT-systems can also provide a higher quality of life for employees since the use of digital information systems can increase flexibility and autonomy. However, on the other hand it poses the risk for employees to be accessible during hours where they are not supposed to work and therefore could pressure employees to unhealthy working habits.

The role of managers has been greatly affected by the introduction of MIS as well as the operational sub systems included in the business processes. Rainer and Prince (2021) states that managers role of decision making has been affected by the ability to get real-time data to act upon. This increases the stressfulness of the decision making since actions should be based on the real-time information, hence decisions should be made as close to the point of information transfer as possible. However, these MIS also provides multiple tools to lower the time spent on business analysis. Due to the increased information flow towards managers each manager can become more efficient and manage a greater number of activities which ultimately could reduce the number of middle managers and hierarchical levels needed in a organization (Rainer and Prince, 2021).

In the inbound logistics operations, several different information systems are used in order to increase efficiency of different processes in the organization. According to Nettsträter et al. (2015) the most influential information systems used in inbound logistics are Enterprise Resource Planning (ERP), Warehouse Management Systems (WMS), Transport Management Systems (TMS) and Supply Chain Management Systems (SCMS). This paper focuses on the Transport Management System but in order to understand the complex process of implementing a TMS one must understand the connection to the other systems included in the logistical processes. Nettsträter et al. (2015) states that when ERP systems were introduced in the 1990s the functionality was focused on monitoring the resources of the organization and enable planning activities to be more efficient through better information sharing and organizational visibility. However, today, some organizations have very sophisticated ERP systems that stretches beyond the logistical activities (inventory management and disposition) and offers functionality for a large variety of organizational activities such as, finance, accounting, manufacturing and R&D. Furthermore, the major functionality of a WMS is controlling warehouse operations such as, inventory level, item location and transportation means. However, according to Nettsträter et al. (2015) most of the WMS used today are integrated with management systems in order to optimize complex warehousing activities. Lastly, the SCMS is a tool for managing inter organizational processes with multiple actors that are involved in activities such as manufacturing, transportation or distribution. All systems mentioned above are important for a well functioning inbound logistics operation and should therefore be considered when implementing a TMS.

2.2.1 Transport management systems

As described in previous section Transport Management Systems (TMS) are one of the crucial IT-systems involved in inbound logistics. The need for TMS is derived from the increasing complexity of transportation networks of large organizations (Nettsträter et al., 2015). Manufacturing organizations with multiple suppliers and transportation service providers have large amount of information that needs to be shared to ensure desired transportation quality is achieved.

In order to enable organizations to get control over the information flow regarding complex transportation networks the TMS enables realtime updates of informatiton as well as information storage related to the transportation processes and all the actors involved (Barreto et al., 2017; Nettsträter et al., 2015). The increased pace of information sharing enables the actors involved to take fast decisions on what-, how- and where to transport. Furthermore, using a TMS will increase the information gathering from the transportation process such as, location tracking with the use of GPS, disruptions on ceratin routes or areas and fluctuations in freight costs (Barreto et al., 2017). According to Rutner and Gibson (2002) organization that have an existing TMS generally gather more information about their transportation activities than organization that does not utilize this type of system. The organization that gather historical data from their transportation can utilize the information to continuously evaluate and improve their processes. An example of this stated by Rutner and Gibson (2002) is the increased accuracy of forecast for those organizations using a TMS.

The functionality of a TMS can vary depending on what the organization want to accomplish with their system. However, the key functionalities that usually are included in a TMS are order management, shedueling, transportation planning/optimization, tracking and tracing, fleet and resource management and freight cost management (Nettsträter et al., 2015). Having access to these functionalities within the inbound logistic department of an organization will not only provide better understanding of their transportation accuracy but also enable tracking of filling rates and resource efficiency in order to optimize their processes.

2.2.1.1 Implementation of a Transport Management System

Investigating the prerequisites for implementation of a TMS requires insight in system implementation theory. The literature reviewed for implementation has a broader scope, looking at ICT, but since TMS is a type of ICT the same principles can be applied to this case. In the study conduct by Perego et al. (2011), several factors was established as important for understanding ICT implementation. Firstly, the characteristics of the company, as well as the current ICT adoption level of the organization have a large effect on future implementations. Organizations with high level ICT adoption is more likely to have a positive culture towards new implementations whilst organizations with low level of ICT might be more sceptical. Additionally, the different transportation modes have reached separate stages of ICT maturity, which often result in incompatibility i.e. when the ICT system of

a railway operator is trying to communicate with an ICT system of a road haulier (Perego et al., 2011). Furthermore, the application in use is important to fully understand the implementation process. Perego et al. (2011) states that most of the logistical ICT applications in place are related to financial activities or warehouse management whilst other logistical ICT such as TMS are lacking behind.

Perego et al. (2011) also discuss how the level of integration between current systems and the implementation is crucial for a successful implementation. Therefore, the more systems that are intertwined the higher complexity of the implementation process (Perego et al., 2011). Buijs and Wortmann (2014) discuss several issues regarding how actors use their IT-systems and the lack of integration between them. One example identified by the authors is how information from systems capturing real-time data and information from planning systems are not reflected in the TMS used. Another issue is how limited IT-integration prevents joint optimization. Instead, planning and optimization occurs on a local level, but there is no collaborative effort towards optimizing the transportation network as a single unit. Buijs and Wortmann (2014) also emphasize that it is important to connect different types of systems with each other to not limit the information access, instead of simply connecting different TMS applications with each other as many actors have previously done. Perego et al. (2011) further discuss how there is a lack of knowledge among actors regarding which combination of IT-systems to use in order to improve collaboration, as well as how to integrate those systems with each other.

The inbound logistics operations in this case study is to a high degree centralized which becomes another aspect to consider regarding the implementation. Centralization refers to the hierarchical structure of an organization and the division of responsibilities for processes between these hierarchical levels (Quester and Conduit, 1996). For example, a process is centralized if the central body of the organization manages a process for several subsidiaries or branches instead of letting the branches and subsidiaries handle the process on their own. For logistical operations, there are multiple processes that can be either centralized or decentralized such as purchasing, warehousing, transport management, distribution etc. As presented by Prechel (1994), a major reason for centralizing business processes is to minimize risk by increasing governance over the process and being able to monitor the entirety of the process. However, the greater the distance between the decision-making body and the operational actor, the level of flexibility and pace of decision-making decreases. Due to this centralized structure of the transport management process, the fast paced communication channels becomes key in order to facilitate flexibility throughout the organization Abrahamsson et al. (2003). As argued by Quester and Conduit (1996), the relationship between standardization and centralization is important in order to reap the rewards from the structural strategy of centralization. Standardization in the sense of business processes refers to creating organizational guidelines in order to ensure repeatability and consistency for processes and activities (Tassey, 2000). Furthermore, according to Ross (2003) using standardized IT-solutions lead to cost savings and increases security, maintainability and reliability. Therefore, implementing a TMS to create a standardized IT-structure that

matches the organizational structure would further increase the positive effects of having the transport management process centralized. Whilst also increasing its flexibility, maintainability, security and reliability as well as reducing costs.

Furthermore, by implementing the TMS, changes will occur for multiple actors involved in the process and therefore it is important to identify how to overcome the organizational inertia (Godkin and Allcorn, 2008). Specifically, the psychological inertia is interesting in this case where Godkin and Allcorn (2008) describes the natural psychological phenomenon to resist change regardless of how great the need for change is. In addition to psychological inertia, the insight inertia will also play a large role in implementation of a system of multiple actors. To overcome insight inertia, Godkin and Allcorn (2008) states that all actors affected by change needs to understand the reasoning behind the change and what positive effects it will contribute. Since the implementation of a TMS is reliant on multiple actors, each actor must understand why this implementation is necessary in order to play their part in the process.

With this said, the implementation of new systems also needs to hurdle the external barriers effecting the company. According to (Forster and Regan, 2001), one of the major external barriers are the influences of other actors in the supply chain. The relationships existing between the actors might be crucial in the implementation process since trust is needed between actors in order to share information. In addition the technological requirements must be met by the actors in the supply chain in order for implementation of new ICT to work efficiently (Pokharel, 2005; Zeimpekis and Giaglis, 2006).

2.3 Information attributes

Jacobsson et al. (2017) has defined information attributes as "*actual transmitted information*", which is comparable to the forth facet of communication *content* as presented by Mohr and Nevin (1990) and refers to the information in itself - what the message is or what is said. The actual information that is being transmitted is referred to as existing information attributes, whereas information that could be used to improve the situation of a company or an actor is called desired information attributes (Jacobsson et al., 2017). Oppenheim et al. (2001) describes the value of information attributes and that it should be treated as any other type of resource. The authors discuss how information attributes can influence effectiveness and add value to an organization. Koenig (1992) further argue that information, and therefore information attributes, can boost innovation and productivity of an organization. Having identified the correct information attributes could also help minimize risk in innovation (Oppenheim et al., 2001). If all actors within a network receive and share all appropriate information attributes, the risk of innovation is minimized since they can utilize internal information to improve decision-making, increase trust between the actors and enhance bidirectional communication channels (Oppenheim et al., 2001). Moreover, according to Zhao and Goodchild (2013) the shape of the information can also affect the organization. For example, the use

of time windows instead of specific estimated times can reduce the sensitivity of deviations or inaccurate information.

In order to identify the information attributes, Oppenheim et al. (2001) describe how the context must first be defined, which in this case is a network. Within the network there are both internal and external influences and actors of different hierarchical levels. The various actors have varied information needs and uses, where each actor contributes with information and receives information from other actors. Together the actors can build an adequate base of information attributes to remain in coalition. By first identifying all actors within the network it is later possible to identify which information each actor currently possess as well as what information attributes they require to improve the effectiveness of the network. It is also crucial that all identified actors are considered and included in the network structure for long-term success and effectiveness (Oppenheim et al., 2001. Angelmar and Stern (1978) mention that information attributes can be analyzed though the use of pre-determined categories while Frazier and Summers (1984) express that the contents also can be identified by asking the actors involved in the interaction.

3 Methodology

The following chapter describes how the research was conducted. The chapter explains the choices made for the research approach, participant selection and how the data was collected. It further discuss how the collected data was analysed and the ethical considerations made throughout the research project.

3.1 Research approach

As previously stated, this thesis is based on a case study at Volvo Cars. Yin (2014) describes the case study approach as an investigation of a real-life context that allows for in-depth and detailed research. Darke et al. (1998) further describes how case study research is well-suited for development of IT-systems. Since the purpose of this report is to investigate the prerequisites for a successful implementation of a rail freight transportation route with an existing TMS for inbound logistics, the case study approach seems ideal.

Case studies can provide both deductive and inductive results (Baškarada, 2014), whereas an abductive approach combines the two in a *"continuous interplay between theory and empirical observation"*(Dubois and Gadde, 2002). The abductive approach allows for successive modification throughout the research period as new empirical or literature findings could give new insights during the process (Dubois and Gadde, 2002). Given the aim of this report it was evident that new insights would be found as the research progressed, which is why this report is inspired by the abductive approach.

If findings of this report is implemented it is very likely to result in a change in working habits for the stakeholders involved and according to Chaudhry (2018) this is something that needs to be considered. Chaudhry (2018) states that it is essential to consider employee attitude in order to successfully implement change. With this in mind, information and opinions were collected from representatives from all of the affected stakeholders in order to gather as thorough of a perspective as possible. Given the nuanced characteristics of this type of data, a qualitative approach is preferred based on Lind (2014). Lind (2014) also claim that a qualitative approach allows for the opportunity to capture circumstances and details that would not present themselves in a quantitative study. Since the affected stakeholders could either resist or support the change (Armenakis et al., 1993), it is important to capture the details such that the risk of resistance is minimized. This effect aligns with the claim by Lind (2014) as to why a qualitative method is preferred. Furthermore, the flexible nature of the qualitative approach (Maxwell, 2013) suits the abductive-inspired approach chosen.

To provide a comprehensive perspective, three different models were used to evaluate the results in relation each of the three research questions. One model for each research question. These models include the industrial network approach, the best-worst method and a model for implementation evaluation. The three models

are further described in the following sections.

3.1.1 RQ1: Industrial network approach

The industrial network approach (INA) is a model developed with the aim to analyze complex business networks by breaking down the network into three components; actors, resources and activities. In this network, the three components are inter-related - actors perform activities and consume resources in order to add value to other resources (Hakansson, 2015). This model has, since its development, been used in multiple studies analyzing transportation networks (Woxenius, 1998; Stefansson and Lumsden, 2009; Sternberg et al., 2013). In order to understand the rail freight network in its entirety, the industrial network approach was used to firstly identify all the actors involved within the network. Once all actors had been identified the model was used to structure an interview guide, which was used to interview all the identified actors of the network. This was done to understand what resources each actor controls and what activities each actor performs. According to Hakansson (2015), it is important to understand how the activities in the network are linked together and how actors affect each other. Therefore, the model was used to identify the chain of activities conducted, and how these activities effect adjacent activities in the chain. Furthermore, the resources controlled by each actors plays a part in the prerequisites for the implementation of a TMS. The model break down resources based on their characteristics such as, heterogeneous, human and physical and if the resources are dependent on other resources (Hakansson, 2015). These characteristics was used to develop knowledge of how resources such as IT-systems and communication tools was used by different actors and what activities was linked to each resource.

3.1.2 RQ2: Best-worst method

The best-worst method (BMW), presented by Rezaei (2015), is a model used to *"solve multi-criteria decision-making (MCDM) problems"*. When faced with a multi-criteria decision-making problem, several alternatives needs to be evaluated based on a set of criteria such that the best possible alternative(s) can be selected. There are several models in existence that can be used to solve such a problem, where the analytic hierarchy process (AHP) is the the most extensively used to date (Mi et al., 2019). Rezaei (2015) has therefore compared the BWM with AHP and concluded that the BWM has an edge. One reason is that the BWM requires less comparison data than other models. Another reason is that, based on the results from the study made by Rezaei (2015), the BWM provides more consistent comparisons, which in turn deliver more reliable results. These findings are verified by Mi et al. (2019) who agree that the BWM outranks the AHP in terms of reduced comparison complexity, less amounts of pairwise comparisons required and a higher consistency, which once again makes the BWM more reliable. The BWM is based on selecting a best and a worst criteria and then using these criteria as a reference for comparison. The best criteria is defined as the *"most desirable and/or most important"* while the worst criteria refer to *"the least desirable and/or least important"* (Rezaei, 2015). A weight is then calculated for each criteria determining the relative impact of each criteria.

The total score of each attribute is finally calculated based on the performance of the attribute in all criterion.

Once the information attributes was gathered in the data collection process, the BWM was selected with three criteria determining the score of each information attribute. These criteria was determined based on literature regarding implementation of IT-systems. Both Bingi et al. (1999) and Nah et al. (2001) has studied implementation factors for ERP systems which can be compared to the implementation of a TMS. Therefore, based on their studies the criterion was boiled down to three major areas; (1) *Effect on the process*, (2) *Ease of implementation* and (3) *Maintenance*. When developing the criteria it was important that the criteria was mutually exclusive whilst being commonly exhaustive. *Effect on the process* refers to the operational and strategic effect that the information attributes contributes when being communicated. *Ease of implementation* evaluates the cost, time and resources needed for the implementation of each information attribute. Lastly, *Maintenance* assess the workload and resources needed to communicate each information attribute in the operational work. These criteria was confirmed to be including all necessary information in order to classify each information attribute according the the focus group. These areas were determined as the criteria for the BWM evaluation of the information attributes. The criteria were then weighted relative to each other to determine the impact of each criteria. Lastly, the information attributes could be ranked based on their performance in each criteria, gaining a score on a scale from 1-5 where a 5 corresponds to a good result and a 1 corresponds to a bad result. Furthermore, a final score for each information attribute was determined. The result from this process is presented in Section 4.2.4.3

3.1.3 RQ3: Model for implementation evaluation

In order to evaluate the potential effects of a TMS implementation, a method is necessary to conduct the evaluation. After extensive research to find a suitable model, nothing was found that fit the requirements searched for. However, a paper by Holsapple and Sena (2001) provides a method for analyzing the effects of implementing an ERP system. Given that the implementation of a TMS versus an ERP could be argue to have similar effects, it was decided to use this paper as a basis for evaluating the effects of a TMS implementation. To make this method suit the question posed in RQ3, the method presented by Holsapple and Sena (2001) was somewhat adjusted and simplified.

The method presented by Holsapple and Sena (2001) divides the effects of an IT-system implementation into two sections; positive and negative effects, where the goal is to provide organizations with an overview of how the implementation of the IT-system would affect them. The method is developed through the use of several literature sources in order to provide the most prominent and expected outcomes of an IT-system implementation. The two split sections consists of relatively long lists of expected outcomes. To better address the contents of this report and to allow for a more effective evaluation, the lists were compressed into groups of positive and negative attributes. The positive attributes associated with an implementation of an IT-

system include (1) *Decision-making benefits*, (2) *Communication and coordination improvements* and (3) *Organizational competitiveness*. *Decision-making benefits* refer to aspects of the implementation that would aid decision-making. These aspects include an enhanced ability to process data and knowledge related to the system, shorter decision-making times, reduced costs of decision-making, increased reliability of decisions due to increased access to accurate data as well as stored data that could be used as evidence for decision-making. The second aspect being *Communication and coordination improvements* refers to how an IT-system implementation could improve communication and coordination both within an organization, but also across organizational borders. *Organizational competitiveness*, which is the third aspect refers to how the organization who implements the IT-system can gain an increased competitive advantage as a result of the implementation.

Moving on to the negative attributes. Holsapple and Sena (2001) categorize the negative attributes into a few limitations. The limitations applied for this report are (1) *Technical issues*, (2) *Human issues*, (3) *Organizational infrastructure* and (4) *Economic limitations*. *Technical issues* refers to the potential technical limitations an organization can experience during and after the implementation. For example, the organization not having the technical capabilities in place to execute parts or the entire implementation or the inability to fully utilize certain benefits that normally come from an implementation. The technical issues can also include performance inabilities of current software, hardware or networks used by the organization. *Human issues* is another limitation that encompasses human-related issues that an organization can experience as the result of an implementation. These aspects include resistance to change among affected individuals, organizational culture as well as the unwillingness to share knowledge or to collaborate during and after the implementation phase. *Organizational infrastructure* is the third limitation which involves elements such as organizational rules, policies, regulations and procedures that are incompatible with the implementation and could therefore inhibit its execution. Finally, Holsapple and Sena (2001) discuss the *Economic limitations* of an implementation. This refers to the expenses involved with purchasing or implementing certain resources that are required to accomplish an implementation.

Using the method described, the contents of the data collected could be categorized into the positive and negative attributes presented in order to provide a clear and extensive presentation of how a TMS implementation could affect Volco Cars' rail freight network.

3.2 Selection of participants

The process of selecting the participants for the interviews and focus groups greatly affect the data provided. In order to efficiently select the correct participants and a sufficient number of participants Alsaawi (2014) states that the selection process should be fair to the greater population. To account for this, representatives from all parties involved in the train process were selected for interviews. For all parties but one, at least two representatives were selected from each party in order to expand

the possibility of gathering the relevant data needed. Given that Plant A is the main plant, additional participants were selected from this plant since they were able to provide a substantial amount of useful information. However, as Guest et al. (2006) states there is a risk of overestimating the saturation when researchers become saturated in one category of their research subject. In order to avoid this, the interview structure was divided into different categories through the use of an interview guide and during the codification of the interviews all categories were evaluated in order to ensure that the data collected was sufficient enough to answer the three research questions proposed.

3.3 Data collection

The data for this report was primarily sourced through digital and physical interviews. The choice is grounded in the flexible character of interviews and the ability to gain comprehensive information (Lind, 2014; Miles and Gilbert, 2005). As already established, it is important to gain support from all stakeholders to successfully implement change (Armenakis et al., 1993). Given that the implemented change will be used on a daily basis it is important that all stakeholders are satisfied. Using interviews therefore enables an in-depth method of data collection, ensuring that details such as individual opinions are included and later considered such that the best possible solution could be found. In line with this reasoning, Yin (2014) consider interviews as an essential source of data when it comes to case studies while Hannabuss (1996) states that interviews recognize attitudes, which further emphasize its relevance in relation to the discussion around the claim made by Chaudhry (2018).

In order to have a structured way of conducting the interviews, a main interview guide was created, which is recommended by Lind (2014). Based on Beechem et al. (1998), using an interview guide helps the interviewer gather data in a methodical manner, which simplifies data handling and data analysis further down the line. The main interview guide is based on questions that provide data for all research questions. The interview guide, which can be seen in Appendix A consists of four sections, one for each of the three research question and one with general questions at the start. Attaching the interview guide to the report improves the readers ability follow the research process which according to Patel and Davidson (2016) improves the authenticity of the study.

Since each interviewee was able to provide data for different research questions, some of the questions used during the interview was selected based on who was interviewed. On top of this, a semi-structured interview format was used since it provides flexibility during the interviews (Patel and Davidson, 2016). Given the complexity of mapping and understanding the current situation at Volvo Cars, having the ability to pose direct follow-up questions (Baškarada, 2014) enabled collection of data that was not included in the interview guide. Daymon and Holloway (2010) also explain how this interview style help understand the interviewees perspective, which once again relates to the previous discussion regarding employee attitude. By

having the ability to select questions based on the interviewee, depending on their background and knowledge as well as rephrasing the question when necessary to add clarity, misunderstanding could be minimized. This improved the quality of the data collected and helped ensure that correct and relevant information was received, improving the reliability of this study (Patel and Davidson, 2016)

In combination with the interviews, primary data was also collected through focus groups. The interview method used was focused towards collecting the initial bulk data used in the report. The focus groups were later used to receive input on the progress made towards finding a solution. The focus group meetings were constructed of personnel working in Plant A's logistical operation and optimization. There are several reasons behind this. Firstly, they have the most experience of using the TMS and therefore have the ability to provide valuable input. Secondly, they are the main plant of the logistical operations and the most knowledgeable regarding the entire train process. Lastly, they are the supervisor/contractor of this case study and therefore their opinion is of significance. According to Basch (1987) focus groups is an effective method to gain ideas and opinions from several participants at the same time. This way, comprehensive and valuable input regarding the progress and how to go forward with the study was gathered in an effective manner, increasing the possibility of a successful change and implementation. Basch (1987) further express how focus groups can achieve synergy as participants can help each other disclose and expand upon information, resulting in a deeper understanding and more refined data. Therefore, the focus groups were used for workshops to identify how the information attributes should be classified according to the internal practices of Volvo Cars. Furthermore, the focus groups were used to generate necessary information regarding the BWM process. Information provided by the focus group was processed and presented back to the focus group in order to get further feedback on the findings. Using an iterative approach is encouraged when working with development since it provides progressive generation of knowledge and implements changes continuously (Wynn and Eckert, 2017). With this said, it is important to note that focus groups tend to discourage individual reflection as the participants are influenced by each other (Baškarada, 2014). However, given that it is impossible to satisfy every individual opinion when introducing change, acquiring a collective opinion is considered both effective and satisfactory, making focus groups an optimal method for this study.

Furthermore, personal observations was used to complement the two previous data collection methods. Since both authors of this thesis have previously worked at the company, personal experience of using the TMS as well as familiarity with the company context is considered useful data to include in the report. Hennink et al. (2020) describe how observations are commonly used supply supplementary information, which aligns with the intention of this report. Given that it is important for the success of the thesis to understand the case from a holistic perspective, observations allow for the inclusion of additional context that may not be discussed in focus groups or interviews (Hennink et al., 2020). On top of previous observations and experience, new observations were made in terms of visiting the terminal at Plant A

to gain a visual perspective of the transportation process and to observe employee workload and behaviour. Throughout the duration of the study, employee workload and behaviour at the Plant A office was also observed on occasion. Additionally, gaining access to the TMS once again allowed for testing functions and exploring areas of the TMS that had not been used during previous employment, along with a new investigative point of view. Hennink et al. (2020) use the term 'participant observation' to describe the observation methods described above and explain how using other senses such as sight, smell and touch could improve the researchers understanding and increase the quality of the data.

During the first focus group meeting, it was suggested to use a survey to efficiently collect the opinions of several participants regarding what information attributes are the most important. According to Paradis et al. (2016), surveys is an ideal data collection method for gathering knowledge from a predetermined sample of participants. Van Selm and Jankowski (2006) further highlight how the use of online surveys is an efficient method of collecting data.

3.3.1 The data collection process

The data collection process can be divided into two phases. One containing the interviews and initial learning of Volvo Cars's train process and the second phase diving deeper into the issue and studying the information and process closer. In table 1 the data collection process has been summarized based on what information was needed in order to sufficiently answer each research question and what research method was used to gather said information.

Table 1: *Summary of data collection process*

RQ	Information needed	Research method	Roles of participants	Analysis model
RQ1	Actors, resources, activities	- 15 of the semi-structured interviews - Pre-studies - Personal observations (the visit to the Plant A terminal)	- 3 Logistics operators - 3 Logistics optimization employees - 3 Logistics operations managers - 2 Supply chain coordinators - 1 Logistics operations teamleader - 1 Terminal operator - 1 Terminal manager - 1 Supply chain manager	Industrial network approach
	Relationships and connections	- 14 of the semi-structured interviews	- 3 Logistics operators - 2 Logistics optimization employees - 3 Logistics operations managers - 2 Supply chain coordinators - 1 Logistics operations teamleader - 1 Terminal operator - 1 Terminal manager - 1 Supply chain manager	
	Technical information of the process	- 15 of the semi-structured interviews - Internal documents - Personal observations (studying and using the TMS)	- 3 Logistics operators - 3 Logistics optimization employees - 3 Logistics operations managers - 2 Supply chain coordinators - 1 Logistics operations teamleader - 1 Terminal operator - 1 Terminal manager - 1 Supply chain manager	
RQ2	Information channels and communication methods	- 13 of the semi-structured interviews - 1 of the two focus group meeting - Personal observations (the visit to the Plant A terminal)	- 2 Logistics operators - 3 Logistics optimization employees - 2 Logistics operations managers - 2 Supply chain coordinators - 1 Logistics operations teamleader - 1 Terminal operator - 1 Terminal manager - 1 Supply chain manager	Best-worst method
	All potential and impactful information attributes	- 15 of the semi-structured interviews - 1 of the two focus group meeting - Literature review	- 3 Logistics operators - 3 Logistics optimization employees - 3 Logistics operations managers - 2 Supply chain coordinators - 1 Logistics operations teamleader - 1 Terminal operator - 1 Terminal manager - 1 Supply chain manager	
	What information is absolutely necessary and what can be implemented at a later stage	- Both focus group meetings - 1 survey	- 2 Logistics operators - 3 Logistics optimization employees - 1 Logistics operations managers - 1 Logistics operations teamleader	
RQ3	Potential operational effects	- 14 of the semi-structured interviews - 1 of the two focus group meetings - Personal observations (TMS knowledge and the visit to the Plant A terminal)	- 3 Logistics operators - 2 Logistics optimization employees - 3 Logistics operations managers - 2 Supply chain coordinators - 1 Logistics operations teamleader - 1 Terminal operator - 1 Terminal manager - 1 Supply chain manager	Model for implementation evaluation
	Potential strategic effects	- 13 of the semi-structured interviews - 1 of the two focus group meetings - Personal observations (TMS knowledge)	- 3 Logistics operators - 3 Logistics optimization employees - 3 Logistics operations managers - 2 Supply chain coordinators - 1 Logistics operations teamleader - 1 Supply chain manager	

The first phase of the data collection process was mainly focused on conducting interviews with the actors involved in the rail freight network. In total, 16 interviews were conducted. During all interviews both authors was present where one was responsible for leading the interview whilst the other was responsible for taking notes. Each interview was started with asking consent for recording the interview to make sure no valuable information was lost or bypassed. With regard to the vast geographical spread of the respondent and limited accessibility, some of the interviews were conducted digitally via Microsoft teams. The standardized interview guide was used to pose questions to all the initial interviews but in the later stages during secondary interviews the interview guide altered with more specific questions towards targeted areas where more information was needed. The first phase of the data collection process also included going through internal material from Volvo Cars with

the purpose of getting deeper understanding of their operations and structure. This material included descriptions of their train process, as well as a short pre-study mapping of actors involved in the train process.

The second phase of the data collection process included personal observations such as studying the TMS closer and visiting the terminal of Plant A, focus group meetings to generate more information, and a survey to validate the information collected. The study of the TMS included analyzing how it was used for other transportation modes to get an overview of how the system worked and what features was accessible. Furthermore, it was important to understand what information was stored by the system and could be extracted for strategic purposes. The purpose of visiting the terminal of Plant A was to get first hand experience of how the operational processes work of loading and unloading the train but also to understand what information was important for the terminal operators. The focus group meetings was conducted in person at Plant A with a prepared presentation and agenda in order to use the time as efficiently as possible. The focus group was used to ensure the information collected was complete and that no important factors was overlooked. The focus groups provided guidance in how the information attributes should be classified, were the requested classifications was "Must have" and "Nice to have". "Must have" information attributes refer the information attributes that are absolutely critical for the operations to continue and "Nice to have" is those information attributes that provide value but are not critical. This terminology is used internally by Volvo Cars and will be used throughout this report. Furthermore, since the "Nice to have" information attributes was not deemed critical it was important to rank these information attributes in order to provide guidance on what to prioritize in the implementation.

The ranking process was conducted in two different ways. Firstly, the theoretical mode BWM was used in order to classify the information attributes with regards to the criteria developed with the focus group. Secondly, the "Nice to have" information attributes was compiled in a survey and sent out to workers involved in the train process in order to collect their opinion on what information attributes was the most important for their specific task. During the first focus group meeting, the participants were provided with an initial iteration of the BWM that had been developed using the information gathered from the interviews. After presented with the results of the BWM, the participants of the focus group meeting were allowed to provide their input. The information gained from the meeting was then used to generate a second iteration of the BWM. This was then evaluated again by a second focus group meeting, with some new participants and some participants from the previous focus group. The final step of the data collection process was creating the survey with the purpose to compare information gathered during the interviews to the opinion of the first hand workers of the TMS. The survey was sent to 7 participants at Plant A since it was decided during the focus group meeting that their input is the most valuable. The survey listed the 7 selected "Nice to have" information attributes along with an explanation. The participants were asked to select up to four of what they considered to be the most important information attributes

that were listed. They were also asked to rank their selection(s) as well as provide an explanation for why they regarded them as the most important.

3.4 Data analysis

During the interviews and focus-group meetings, detailed notes were written. These notes were later sorted and codified. Accounting for the comprehensive notes made and enabling the ability to make a time efficient analysis of the data that was collected, the decision was made to only transcribe parts of the collected data, such as cases when the notes were not detailed enough.

To process the collected data, notes from each interview was refined and codified directly after each interview. This was done to captivate on having the information fresh in memory and to be able to discuss the data collected. The data was codified using excel spreadsheets, which is suggested by Tracy (2013) as an appropriate digital tool to aid the codification of data. In line with Magnusson and Marecek (2015), several thematic categories were created based on the three research questions and the interview guide used. This allowed for an efficient structure and overview of the data. The use of thematic categories is underlined by Lind (2014) as an effective method to handle large amounts of data. To further ease the use of the codified data throughout the extent of this case study, the different themes were color-coded in as recommended by Tracy (2013). The use of color-codes allowed for easy filtration between the information provided by the various interviewees.

In order to analyze the data collected, the data was categorized into the three research questions. Firstly, looking at RQ1 the data collected provide a basis of information in order to map the structure of the rail freight network at Volvo Cars inbound logistics. In order to create a structured map of the operations the industrial network approach was used (Gadde et al., 2003). This model uses three categories in order to encapsulate all vital information for a network to function efficiently. These include; actors, activities and resources. By using the industrial network approach, a complete mapping of all necessary components will be created and serve as a base for the study. Secondly, RQ2 focuses on what important attributes needs to be considered when implementing the train transportation routes into the TMS. The method chosen for analyzing this data is the best-worst method (BMW). The motivation behind this choice can be seen in section 3.1.2. With this said, the first focus group meeting provided much input that shaped the results for RQ2, where the BWM became less prominent. Given that Volvo Cars is the client, it was decided that their input and had higher authority and importance than the model used. Furthermore, to analyze the potential effects of the TMS implementation as stated in RQ3 a framework will be used based on an analysis method by Holsapple and Sena (2001). The framework is used to help categorize the potential positive and negative effects that the implementation could have, which was gathered during the data collection process. A further explanation of the framework used and the motivation behind can be read in section 3.1.3.

3.5 Ethical considerations

The ethical considerations of this report is based on the recommendations made by Lind (2014) regarding research ethics. According to Lind (2014) the following considerations needs to be acknowledged in regards to the participants involved in the research; *consent, confidentiality and anonymity*. Identical considerations are presented by Munhall (1988), who also stress the ethical obligation of research.

To confirm consent among the participants, the purpose and proceedings of this research paper was explained. Before each interview, all participants confirmed their consent of participation as well approval of documentation in the form of audio recording and notes. They also had the opportunity to ask questions and were informed that they were free to withdraw their participation at any moment during the process, up until publication of the report. To ensure consent before publication, a final approval from all participants concerning the contents of the final draft was achieved before the report was finally published. This approach aligns with the features of consent demonstrated by Munhall (1988) and Lind (2014).

Given that the thesis permeates a private company, both company and ethical confidentiality are crucial considerations to be made. To fulfill this criteria, a high level of transparency regarding the information needed and what it will be used for was given to all participants, which according to Munhall (1988) is a way to prevent participants from giving unnecessary and potentially confidential information that is not needed for the purpose of the study. On top of that, the information generated was handled in a manner that no outsiders could access the information. Once the final report was submitted, all collected material was destroy, which ensures that the confidentiality of the study will remain in the future.

In line with the previous discussion, some of the data collected could be considered sensitive information, especially when it comes to personal opinions regarding the implementation. Both Lind (2014) and Munhall (1988) stress how it is important to protect the participants. If the participants know that they will remain anonymous throughout the study, they are more inclined to first of all participate in the study, both also be more open towards sharing information. Therefore, personal data of all participants will remain anonymous in this report. Only general details of the participants will be shared such that it is clear which stakeholder they represent since it is believed this information is important for the result and clarity of the report.

4 Empirical findings

This chapter declare the empirical findings from the data collected. The chapter has been divided with respect to the three research questions posed. Firstly, an overview as well as a more detailed description of the rail freight network at Volvo Cars is presented. Thereafter, communication channels are described and identified information attributes are presented and evaluated. Lastly, the potential effects of the TMS implementation is discussed.

4.1 Findings related to RQ1: Actors, resources and activities

To provide an initial understanding of the rail freight network at Volvo Cars, the following section presents an overview of the rail freight network and how cargo is transported between the plants. Section 4.1.2 will later present a more detailed explanation of all the actors involved in the network through the scope of the Industrial Network Approach.

4.1.1 Mapping the rail freight network

Within the rail freight network there are several actors involved, including three production plants, two train operators and one third party logistics provider (3PL). The three production plants consists of Plant A, B and C. Plant A and B are assembly plants and Plant C produces components for these two plants. For transportation both diesel and electric locomotives are used, pulling wagons that carries containers. The rail freight network consists of two separate routes, one domestic and one crossing international borders. The two routes are displayed in Figure 1 below.

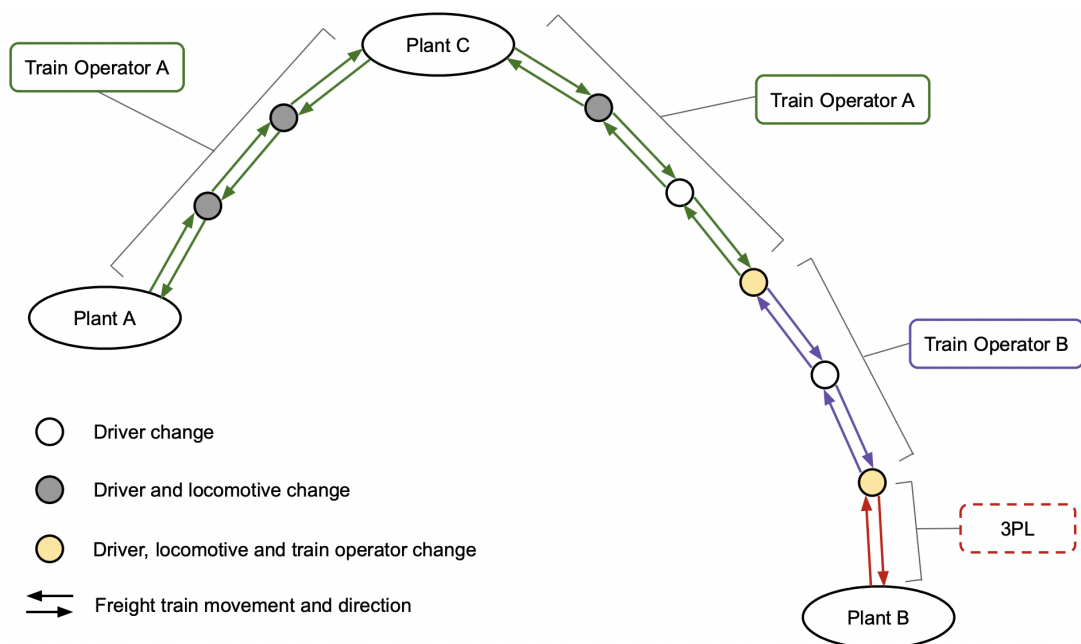


Figure 1: A map of the train process

The domestic route run between Plant C and Plant A, where Train Operator A is responsible for operating the train between the two plants. From Plant C, components are transported to Plant A to be used for production. The empty containers are then filled with packaging material and returned to Plant C. The packaging material is specifically designed by Volvo Cars to transport the components between the plants. The train departs 3 times per day in each direction and 15 times per week since it is only operating on weekdays. This results in a total of 30 departures per week if both the component and return flows are included. Each locomotive has a capacity to pull 29 wagons, where every wagon can be loaded with 3 containers, meaning that each train has the ability to carry a total of 87 containers. In sum, a maximum of 2310 containers per week can be transported on this route, counting both flows. With this said, the amount of containers transported depends on the material requirements at the assembly plant (Plant A), meaning that all 87 containers are not always necessary.

On average 84 containers are used in the flow, where about 80% of containers are filled with predetermined material-mixes and the remaining 20% are filled with randomized pallet material. One material-mix, for example, consists of a container filled with only the front left doors of a car. Another example is a container filled with only right rear doors. The reason why the this 20% of randomized pallet material exist is to compensate for material shortages at the assembly plants. This shortage could occur in a number of ways, but the most common ones would be damaged material upon arrival or during unloading, corrosion of material, wrong type of material delivered etc.

Since production occurs Monday to Friday at Plant A and the train operates during the same days, there is a balance in the round-trip flow. A so-called one-to-one flow. This means that once the train arrives to Plant A and the containers with components has been unloaded, the same amount of containers are loaded onto the train with packaging material. There is also a system to the return flow, ensuring that the same type as well as amount of packaging material are put into the returning containers. This closes the loop of the entire flow as the packaging material can be reused at Plant C.

During transportation, a change of both driver and locomotive occurs twice along the route as indicated by Figure 1. This is because the railway track for the first short stretches from the two plants are not electrified, requiring diesel locomotives to be used. Once they reach the electrified railway track (which constitute the majority of the route), the diesel locomotives are switched to electric such that the environmentally-friendly qualities of rail freight can be utilized.

The international route is a bit more complex as displayed by Figure 1. It is substantially longer due to the geographical location of Plant B in relation to Plant C. Similar to the domestic route, components are transported from Plant C to Plant B with a return flow of packaging material back to Plant C. Each train also has a max capacity of 87 containers, but with only one departure per day from each

directions. In contrast to the domestic route, this route is operated every day of the week, resulting in 7 departures per week, with a total of 14 departures counting both flows. This means that the route carries around 1218 containers every week, depending on if max capacity is utilized or not. Contrary to the domestic route, the international route does not have a one-to-one flow. This is because the train operates 7 days per week while production only runs for 5 days. On top of this, there is no system in place for returning packaging material to Plant C, meaning that a randomly selected type of packaging material is put into each container. Packaging material comes in many different types depending on what type of components are being transported. For example, a type A packaging material is customized for a specific type of component and cannot be used to transport any other component types. Moreover, different types of packaging material are used for the two routes since the two assembly plants assemble different types of products.

As shown by Figure 1, the international route consists of several stops. Similar to the domestic route, the first stretch of railway track from Plant C is not electrified, requiring a diesel locomotive. After the first stop, a new driver transports the cargo with an electrified locomotive until the second stop where another driver takes over as indicated by Figure 1. For the third stop, Train Operator B takes over responsibility and switches to their own locomotive and driver. Train Operator B then changes driver during a fourth stop and at the final stop they hand over responsibility to the 3PL. The 3PL unloads the containers from the train and stores the unloaded containers at their container yard. The containers stay at the yard until Plant B requests the material, in which the 3PL uses a truck with a trailer to transport the container from the yard to the assembly plant (Plant B).

On the occasion that the train transportation is delayed and the assembly plants require the material before the train is expected to arrive in order to prevent a material shortage and a potential production stop, express deliveries are used. The transportation mode used for express delivery is road transportation with trucks. This is because they are not bound to the restrictions of the railway track and their flexibility is therefore favourable. However, it is highly inefficient to transship goods directly from the train to a truck since the train first needs to travel to a hub that carries transshipment equipment, which usually results in a ton of wasted and valuable time. Therefore, new material is picked-up back at Plant C, which is why in some cases time would not be saved and therefore the choice of using express delivery is not justified.

4.1.2 Actors, activities and resources in the rail freight network

The following section provides a more detailed explanation of each actor through the scope of the Industrial Network Approach, including the activities they perform and the resources they possess. The section has been briefly summarized in Table 2 to give an initial overview.

Table 2: *An overview of each actor within the rail freight network*

Actors				Activities	Resources
<i>Name</i>	<i>Departments</i>	<i>Role</i>	<i>Organizational connection</i>	<i>Main activity</i>	<i>Main resources</i>
Plant A	Logistics Operations, Optimization and Terminal Operations	Main assembly plant	Internal	Produces end-products	IT-systems, personnel and physical resources
Plant B	N/A	Secondary assembly plant	Internal	Produces end-products	IT-systems, personnel and physical resources
Plant C	Transport Coordination and Terminal Operations	Component production plant	Internal	Produces components	IT-systems, personnel and physical resources
Train Operator A	N/A	Main train operator	External	Train operator: entire domestic route and half of the international route	Personnel and locomotives
Train Operator B	N/A	Sub train operator	External	Train operator: half of the international route	Personnel
3PL	N/A	Outsourced logistics partner	External	Provides logistical services for Plant B	IT-systems, personnel and physical resources

Table 2 provides a summarized overview regarding the role of each actor, specific departments, connection to the organization as well as main activities and resources. This overview allows for a better understanding of the following subsections who present more in-depth descriptions and explanations of the actors. An important note is that all the information presented below is specifically picked for this case study. Departments, activities and resources of each actor that are considered irrelevant to this report has been excluded.

4.1.2.1 Plant A

Actor

Plant A is the main assembly plant of Volvo Cars, owned by the organization and responsible for producing end-products i.e. finished cars. It also hosts the headquarters of the department for inbound logistics and supply chain management. Because of this, the plant has a central role in the rail freight network. The production site is also responsible to communicate what material is needed for production, which is done by sharing information from their material planning system and production schedule with Transport Coordination at Plant C. On top of this, the most valid departments at Plant to discuss in relation to this study include Logistics Operations, Terminal Operations and Optimization.

Logistics Operations have the main responsibility of overseeing the train transportation flow, conducting daily operational activities. They are therefore the main contact point for actors who want an update regarding a transportation in process. Many of the roles are specifically divided where each employee specializes in a certain area of the transportation flow.

Terminal Operations are responsible for unloading the containers from the arriving train as well as loading the train with new containers filled with packaging material. They are also responsible for identifying that the correct containers and amount of containers have arrived before they unload the components from each container and send them to the correct gate at the assembly plant.

The Optimization department works with optimization and improvements of the rail freight network. Their main tasks involve identifying possible opportunities that could optimize the transportation flow in terms of timeliness, quality, costs reduction etc. They are not involved with performing the daily operations and are therefore more interested in gathering historical data that could be used for long-term improvements rather than smaller operational fixes.

Resources

Plant A has a variety of resources allocated to improve the efficiency of the train transportation flow. The first resource is the personnel at the three departments. The personnel are involved with planning the transportation flow, daily operations as well as handling the incoming goods. Each employee usually has a very specific responsibility assigned, meaning that there is a few dozen employees involved with the rail freight network at Plant A.

In addition to the personnel, Volvo Cars have invested in physical resources. This includes infrastructure such as the last stretch of the railway track entering the unloading terminal. They are also the owner of the containers used for transport. However, these containers are custom built where the height has been adjusted from a ISO-standard 20-foot container. Loading and unloading equipment used at the terminal such as heavy-weight forklifts, as well as office buildings, office furniture and office supplies are also physical resources used at Plant A.

Finally, the main IT-resources used for communication include the Outlook email application, Microsoft Teams and telephones. To structure communication regarding updates of the train transportation Excel spreadsheets is used.

Activities

The most time-consuming activities at Plant A is the operational activities performed by Logistics Operations. This includes monitoring the flow and communicating with the actors involved. The main objective is to ensure that components from the train reaches the unloading terminals in Plant A and B in order to prevent a material shortage, which could cause a production stop. If delays occur they need to alert the assembly plants to check if they can handle the delay. Otherwise they need to solve an express delivery such that the required components reach the affected plant before they run out of material. This responsibility lies on Plant A during day-time and is handed over to Transport Coordination at Plant C at evening- and night-time. Logistics Operations are further responsible to investigating the cause of delays if similar delays occur on a regular basis. To help prevent future delays, they conduct performance reviews of the train operators based on KPI:s and data collected.

Terminal Operations are mostly concerned with the activities of unloading and loading the trains. Three trains arrive at Plant A each day, where they have a time window for unloading and reloading the trains of about three hours during daytime and and four hours in the evening since less personnel is available at that

time.

Optimization perform non-operational activities such as planning and scheduling the train transportations, while simultaneously working towards optimizing and improving the overall train transportation flow. In order to facilitate these improvements they try to gather historical data of previous train transportations, but due to the manual train tracking currently conducted the data available is highly limited and not easily accessible.

4.1.2.2 Plant B

Actor

Plant B is the secondary assembly plant part of Volvo Cars' organization, also responsible for producing end-products in the form of cars. They have a minor role in the rail freight network. First of, the unloading terminal for incoming trains is not part of the plant. Instead, it is outsourced to the 3PL and located in close proximity. Plant B then calls in specific containers to be used for production, where the final delivery of the containers takes place using trucks on a short stretch of road. Because of this, the 3PL handles most of the communication with other actors regarding the train transportation. With this said, Plant B is still responsible for communicating what material is needed for production, which is done in a similar manner as Plant A.

Resources

Since most of the activities are outsourced to the 3PL the resources dedicated towards the the rail freight network is limited. The most viable resources to discuss are the different systems used for communication, which varies between the different actors. For communication with Logistics Operations in Plant A, Outlook email application, telephones and excel spreadsheets are the main resources used. The same resources are used during information exchange with Plant C, but they also use the material planning system to provide information needed to plan the train transportations. Lastly, Plant B has their own internal system which automatically sends signals to the IT-system used by the 3PL regarding which container to deliver to the assembly plant, including specific details such as which unloading gate to use. The signals are triggered by the material planning system who monitors inventory levels.

Activities

The most critical activities at Plant B include ensuring that Transport Coordination at Plant C has the information needed to load the correct components on the train so that production can keep running smoothly. As previously mentioned, the internal material planning system monitor inventory levels and automatically create call-offs for parts that have low inventory levels. The call-offs are automatically received in the SAP system used by Transport Coordination at Plant C. However, if uncertainties arise, Plant B may need to provide Plant C with manual confirmation of what material is needed. Specific containers at the 3PL container yard are called in by the team at Plant B and delivered via tuck to the unloading gate at the

assembly site. Empty containers are loaded with packaging material and sent back to the 3PL yard who at that point takes over responsibility once again.

4.1.2.3 Plant C

Actor

Plant C produces components used in assembly plants A and B and is owned by Volvo Cars. They have two departments involved with the rail freight network; Transport Coordination and Terminal operations. The responsibility of Transport Coordination is primarily to plan the train transportations, but also to monitor them, based on the material need at Plant A and B. They receive this information from the IT-systems used at the two assembly plants and then load the trains accordingly.

The site is divided into two different plants, one older and smaller and one newer and larger. Both plants are used and they are geographically located next to each other with a railway track running between them. Since the two plants produce different types of components the train is split into two parts for loading and unloading and sent to the respective plant. Given that the train routes both start and finish at this site, the train flow is dependent on Plant C and they play an impactful role in the rail freight network.

Resources

There are three main types of resources in Plant C dedicated to the train transportations. Human resources, physical resources and IT resources. The human resources include an administrative team at Transport Coordination consisting of two Supply Chain Coordinators (SCC) who works with planning and management of the train transportations. One of them have responsibility over the domestic route while the other focuses on the international route. At Terminal Operations there are warehouse personnel including one supervisor at each of the two sub plants who are responsible for loading and unloading the trains.

The physical resources used is similar to Plant A. They use the same customized containers and utilize unloading and loading equipment such as forklifts and scanners. They also own the first stretch of railway track, which connects the two sub plants and leads to the electrified and government owned railway tracks.

The main IT-resource used is SAP, which is used to control the train transportations. SAP is an ERP system allowing Plant C to keep track of inventory levels of their own component production as well as the stock levels of the assembly plants A and B. The information provided in this system lays the foundation for decision-making at Transport Coordination. The SAP system is also linked to the unloading and loading process. The warehouse personnel scans every component added to or removed from a container during loading and unloading of the train. The system then registers that the scanned component has either been withdrawn or added to the inventory. The system also automatically send an electronic bill of lading for each container to the transport operator, containing information regarding the con-

tents of the container its made for.

Activities

The activities related to the train transportations at Plant C are almost exclusively operational. As previously mentioned, the two SCCs at Transport Coordination are responsible for planning the train departures and deciding what components are to be loaded onto each train. The planning process and train schedule is conducted together with Optimizations at Plant A. The SCCs at Transport Coordination also perform operational activities, which includes being up to date on material requirements from Plant A and B. If they notice any deviation in the production schedule they need to account for this when planning and/or loading the trains to prevent a potential material shortage. They also takes over responsibility of monitoring the train transportations during evening- and night-time from Logistics Operations at Plant A.

The activities conducted by Terminal Operations at Plant C include loading the trains based on the information received from Transport Coordination. They also ensure that the correct components are loaded into the containers and that the containers are loaded onto the train in the correct sequence. This verification step is done by scanning each component before it is loaded. The IT-system then uses the list of scanned components to automatically generates a bill of lading which is sent to the concerned actors.

4.1.2.4 Train operator A

Actor

Train Operator A is involved in both the domestic and the international flow. They are responsible for operating the trains during transportation. This includes handling and driving the train as well as communicating with the other actors. Train Operator A is contracted by Volvo Cars and the relation is managed by Logistics Operations at Plant A. Their performance is evaluated through monthly meetings Logistics Operations. Train Operator A provides Logistics Operations with data for each train transportation, which acts as a basis for the performance reviews once it has been compiled and analyzed.

Train Operator A is also the contractor of Train operator B. Train Operator A is therefore responsible for the performance of Train Operator B, which means they have an overall operational responsibility for the transportation flow of both routes. During the transportation process, Train Operator A is responsible for communication with the owners of the infrastructure, Train Operator B and updating all other concerned actors if any deviations occur.

Resources

Train Operator A uses physical and digital resources in order to facilitate their train operations. The physical resources include locomotives and the wagons (owned by Volvo Cars) used to transport the containers. To operate the trains they have em-

ployed drivers. They also use (but do not own) the rail infrastructure such as railway tracks, hubs and equipment to perform locomotive exchanges as well as technology provided by the railway owners, which could be used to monitor the trains.

The resources used for communication primarily consist of the Outlook email application and telephones, and for some actors they communicate using the Microsoft Teams application. On top of this, they have digital resources in terms of internal systems used for monitoring train positions and status.

Activities

Train operator A is responsible for both administrative activities as well as operational activities. The general administrative activities include arranging the train fleet with both locomotives, wagons and drivers, communicating with the infrastructure owners regarding updates that might affect the transportation process as well as managing their relations with the Volvo Cars and their subcontractee, Train Operator B. If they receive information that something obstructs the original railway route they are responsible for planning, performing and communicating an alternative route. The administrative tasks also include having regular meetings with the operational team to evaluate their performance and work on improvements.

During the transportation process the train driver is responsible for driving the train and communicating any issues arising during the transportation. For the international route, responsibility of operating the train is handed over to Train Operator B as their driver takes over at the exchange point (see Figure 1). However, Train Operator A is still responsible for the actions of Train Operator B as well as communicating in their regard with the rest of the actors within the rail freight network.

4.1.2.5 Train operator B

Actor

Train operator B is responsible for operating the train for parts of the international route and are under contract of Train Operator A. Their role in the network is quite small when it comes to responsibilities and communication as they mainly operate the train and report to Train Operator A.

Resources

Train Operator B does not have ownership of the physical resources used during transportation other than the drivers they provide. They use the locomotives and wagons provided by Train operator A and Volvo Cars. Similar to Train Operator A, they have an internal system used for monitoring and tracing the train during the transportation. The IT-resources used to communicate with Transport operator A are Microsoft Teams, the Outlook email application and telephones.

Activities

The primary activity of Train Operator B is to operate the trains during parts of the international route. They only administrative tasks include hiring drivers and planning the drivers schedules to match the planned train schedule provided. Their activities also include communicating with infrastructure owners during transportation and reporting deviations to Train Operator A.

4.1.2.6 3PL**Actor**

The 3PL is a company specialized in logistical services. Therefore, parts of the rail freight process has been outsourced by Volvo Cars to the 3PL. Since the 3PL has a long history of logistical solutions they have a high level of expertise in this area and are therefore working with their own routines and resources which differs from Volvo Cars. However, since Volvo Cars is their customer they have to abide to what requirements and changes Volvo Cars want to introduce to the transportation flow. The current agreement involves the 3PL to unload and store the containers as the train arrives to their container yard as well as shunting the containers to and from Plant B as they are needed. The 3PL container yard is located very close to Plant B, which makes transportation between the yard and the assembly plant quick and easy. The main reason for why this yard is used is because the old yard used up its storage capacity. The administrative and strategic role of the 3PL is limited since the development of the transportation flow is the responsibility of Volvo Cars. With this said, they have internal systems and routines in place that improves their work flow in connection to the train transportation process at Volvo Cars.

Resources

The 3PL has similar physical resources in disposal as Plant A, including a container yard for storing containers, railway tracks built with the sole purpose of bringing the train into the container yard, loading and unloading equipment as well as personnel, equipment and machinery needed to operate and manage the trains. Physical resources also include trucks and trailers used to shunt the containers from the container yard to Plant B. The 3PL have also developed their own IT-system connected to the train transportation which they refer to as the "Yard-application". This application takes information from Plant B regarding the containers and components needed and then communicates this directly to the yard personnel such that they know what container to pick up and where to deliver it. The application also has features such as an overview of the yard structure, where the yard personnel gets instructions on where the container is located. Furthermore, the application is used to inform Plant B when the train has arrived, been unloaded and when the containers are ready to be shunted to the assembly plant.

Activities

The main activities of the 3PL is the operational unloading and loading the trains and handling the containers. The trains arrive directly into their container yard where they unload the containers and place them on pre-determined locations de-

pending on the material contained within the container. The 3PL get information from Plant C regarding what has been loaded onto train through an EDI file. They receive a bill of lading for each container including information such as, container ID, component ID, quantities, container weight etc. When all containers has been unloaded from the train and registered in their yard application, they communicate that the unloading process is complete to Plant B. Plant B then inform the 3PL of what containers to transport to the assembly plant and at what times. The transportation process from the yard to Plant B is conducted using trucks and drivers from the 3PL but the unloading process at Plant B is handled by personnel of the plant. When all containers have been unloaded from the train, the 3PL is also responsible for loading the containers containing packaging material back onto the train such that the packaging material needed at Plant C makes its way back.

4.2 Findings related to RQ2: Information attributes

This section aims to summarize the findings related to RQ2 from the data collected. This includes information exchange and information attributes between the actors within the rail freight network as well as an evaluation of the information attributes through the use of the best-worst model and the focus group meetings.

4.2.1 Information exchange between the actors

To visualize the information exchange between the actors, a map of the communication channels has been created as can be seen by Figure 2.

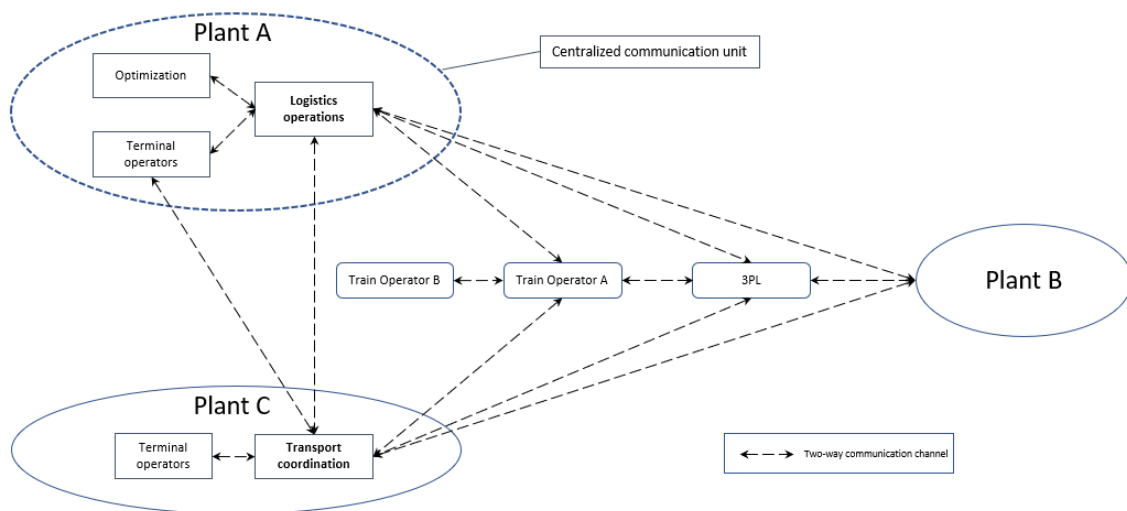


Figure 2: A map of the communication channels between the actors within the rail freight network

As can be seen by Figure 2, the three plants communicate with all of the actors except for Train Operator B. In fact, Train Operator A is the only one communicating with Train Operator B since they are specifically hired by them. As previously stated, Logistics Operations at Plant A are responsible for overseeing all trains in transport during daytime. They therefore have a centralized communication role

and act as an intermediate of communication between the plants and Train Operator A, receiving updates from Train Operator A and spreading this information to whom it may concern. During evening and nighttime, communication occurs directly between Transport Coordination at Plant C and Train Operator A.

Train Operator A is the key actor during transit and they send updates regarding the transportation process to Logistics Operations (Plant A) and Transport Coordination (Plant C). This information exchange can include information regarding the traffic situation, for example if there has been an accident on the road, which forces the train to stop or if there has been a signaling error somewhere along the track resulting in a delay. Information regarding the traffic information is received from the rail infrastructure owners. If a delay has occurred they notify Logistics Operations (Plant A) through deviation reports sent via email. Train Operator A is also solely responsible for communicating with Train Operator B, as indicated by Figure 2.

There are two types of deviation information sent, one weekly report and one regular deviation report. Both reports are filled out manually based on a template. The weekly report consists of an excel file that is progressively updated throughout the week. One file concerns the domestic route and one for the international route. The file contains information regarding all the trains departing in both flow directions for the route in question. Information within the file include train ID (used at departure), departure time, ordinary ETA to final destination, current status, delay in minutes, root cause for delay, new ETA to final destination, expected ETA to different check-points throughout the route as well as specific notes/comments regarding the transportation. However, the weekly report is only used for the international route as it is more complex while the regular deviation report is used for both routes.

The regular deviation report is more of an alert notification, notifying Logistic Operations (Plant A) about a specific delay regarding a specific train. Within this email, the following information is shared; departure date, train ID, delay in minutes, reason for delay, new ETA to final destination and a deviation number. The deviation number exists in case there are several delays for one train. Each time a deviation has occurred a new report is sent with an updated deviation number. This is done to separate the different causes for the delays. However, given that Logistics Operations receives all the emails in a shared inbox with several employees, confusion and miscommunication can occur regarding what the latest ETA is for the train since the latest deviation report could be overlooked or missed.

Another source of confusion during information exchange is the fact that a train has several train ID numbers during transportation for different parts of the route. For the domestic route, three different train IDs are used. This is illustrated in Figure 3.

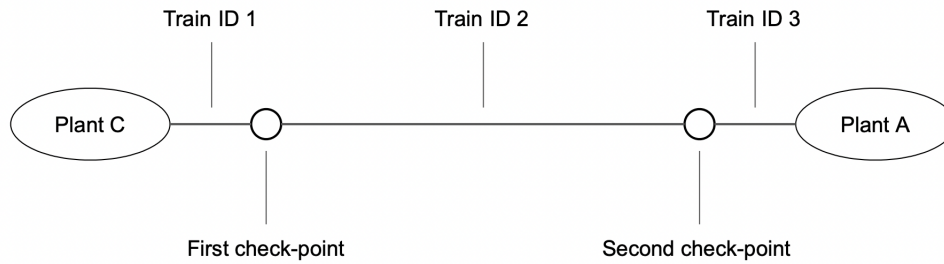


Figure 3: *Illustration of the change of train ID for the domestic route*

As can be seen in Figure 3 the train ID changes depending on what part of the route the train has reached. For the international route, two different train IDs are used throughout the route. According to Logistics Operations at Plant A, this causes confusion during information exchange since it easily can become unclear which train an actor is referring to during communication. For example, one actor may use Train ID 1 when referring to the train while another looks at Train ID 2 or 3. Both actors refer to the same train but due to the different train IDs used confusion arises. On top of this, the same train IDs are recycled everyday, meaning that a train departing 24 hours later than the previous one uses the same ID. This becomes an issue if the previous train is more than 24 hours delayed since this means that there are two trains along the route with the same ID number. Even though this does not occur often, it has happened before and when it happens it adds to the confusion during information exchange between the actors involved.

4.2.1.1 The TMS at Volvo Cars

The TMS used by Volvo Cars is provided by a third party IT-provider, meaning that it is not an in-house creation. With this said, much of the functionalities used have been specifically developed for Volvo Cars, which results in them having a customized version of the TMS. The TMS has been in use since 2014 and has been primarily developed for the road transportation network since it makes up for the majority of inbound logistics. Within the system, each transportation order is based on a two level structure, one higher level and a lower level representing the contents of the higher level. This structure suits road transport since the higher level is represented by e.g. a container and the lower level represents one or several pallets of material inside. However, the train transportation is structured in three levels; the train, the wagons and the containers. This creates an implementation obstacle since it does not fit the two-level structure currently used.

Even though Volvo Cars use a customized version of the TMS, they have close to zero ownership and a very limited ability to create changes within the system without involving the TMS provider. Any desired changes to the system has to be requested from the third party IT-provider, which is both time-consuming and

expensive. Therefore, Volvo Cars tries to avoid small change requests and instead focuses on only requesting large and absolutely necessary changes. The system itself is also highly inflexible where the user is forced to follow the fixed structure of the system and zero customization to the system structure can be made in-house.

The TMS is primarily used by Logistics Operations and Optimization at Plant A since they have the central role of monitoring and managing all of inbound logistics. However, many of the other actors within the rail freight network have either much less experience with the system or none at all.

4.2.2 Existing information attributes

This section contains a summary of the identified existing information attributes based on the results from the conducted interviews and a literature review. Table 3 has then been created to provide an overview of the most important existing information attributes that were identified for each actor. To view a more detailed list containing a description for each information attribute along with references, please refer to Appendix B.

Table 3: *An overview of the identified existing information attributes for each actor*

Actor	Information attributes
Logistics Operations (Plant A)	Train ID, Container ID, ETA, Deviation information, Goods priority information, Time of delivery, Alternative route, Invoicing
Optimization (Plant A)	Train ID, Container ID, Time of delivery, Invoicing
Terminal Operations (Plant A)	Train ID, Container ID, ETA, Deviation information, Estimated pick-up time, Goods priority information, Time of delivery, Capacity of the terminal
Plant B	Container ID, Deviation information, Goods priority information
Transport Coordination (Plant C)	Train ID, Container ID, ETA, Deviation information, Goods priority information, Alternative route
Terminal Operations (Plant C)	Train ID, Container ID, ETA, Deviation information, Estimated pick-up time, Goods priority information, Time of delivery
Train Operator A	Train status, Train ID, Container ID, ETA, Deviation information, Estimated pick-up time, Position, Bill of lading, Driving times for the driver, Breaking status, Queuing status, Alternative route, Invoicing
Train Operator B	Train status, Train ID, Container ID, ETA, Deviation information, Estimated pick-up time, Position, Bill of lading, Driving times for the driver, Breaking status, Queuing status, Alternative route, Invoicing
3PL	Train ID, Container ID, ETA, Deviation information, Estimated pick-up time, Bill of lading, Time of delivery

Logistics Operations (Plant A)

As displayed in Table 3, the most important existing information attributes identified for Logistics Operations in Plant A include *Train ID*, *Wagon ID*, *Container ID*, *ETA*, *Deviation information*, *Time of delivery* and *Alternative route*. Since this

actor act as a communication facilitator between several other actors as previously discussed, it is important for them to have access to *Train ID*, *Wagon ID*, and *Container ID* such that they can provide information regarding the status of a specific train or cargo. *Goods priority information* is another significant attribute since their central communication role requires them to efficiently distribute this information to the concerned actors. Since logistics operations at Plant A is responsible for Train operator A B they also need to process the *Invoicing* information for the process.

Furthermore, as Logistics Operations are responsible for overseeing the transportation and ensuring that the transported material arrives for production in time, they are highly dependent on receiving *Deviation information*. This information can be used to evaluate if the deviation will affect production and whether or not an express delivery is necessary. This is also why *ETA* and *Time of delivery* are of importance to this department. Using this information they can for example compare the new ETA from the deviation report with the ETA for the express delivery to see if time will be saved through the express delivery or not. The deviation information is also used by Logistics Operations as a foundation for performance reviews regarding Train Operator A. The reports can help the department identify if the deviations made starts to escalate, which allows them to quickly take action towards investigating and solving the issue.

Optimization (Plant A)

The optimization team has limited access to the information used during operations. However, they use *Train ID* in order to schedule the train departures for the upcoming month. Furthermore, *Container ID* is used to plan what containers to schedule on each train departure. In the current state they also use *Train ID* to request manual deviation updates connected to specific train departures as well as *Container ID* if information about a specific container is needed. Finally, *Time of delivery* is used to understand transportation patterns, which could be used for optimization. The *Invoicing* information is used to improve the invoicing process with the aim of making an automated invoicing process.

Terminal Operations (Plant A)

Terminal Operations at Plant A have access to *Train ID*, *Container ID*, *ETA*, *Deviation information*, *Estimated pick-up time*, *Goods priority information*, *Time of delivery* and *Capacity of the terminal*. The *Train ID* among other things is used to verify that the correct train has arrived at the terminal as well as communicating the arrival of the train to the actors whom it concern. To identify on which wagon a container is placed, *Wagon ID* is used. *Container ID* is foremost used to identify containers such that the correct container can be localized and identified when a request is sent from the assembly plant. *Container ID* is also used at the terminal to determine where each container should be placed. Additionally, *Container ID* and *Wagon ID* are used to put the containers on the correct wagons since the train is split at Plant C, meaning that the containers and wagons have to be arranged in a specific order during loading.

ETA and *Deviation information* are both significant since Terminal Operations are on a tight schedule for unloading and loading of the train. When the train arrives the forklift drivers need to be ready and have time left on their working shift to ensure that the train is unloaded and loaded within the slotted time frame. During daytime the time window for unloading and re-loading the train is 3 hours and during night it is 4 hours. Similarly *Estimated pick-up time* is necessary to know when the train is supposed to depart from Plant. If the re-loading process takes longer time than planned they must communicate this with the other actors.

Goods priority information is crucial if a certain container needs to be prioritized to prevent a potential production stop. Since the unloading process can take hours it is important to start with the most critical containers. *Time of delivery* is used by Terminal Operations to plan their day-to-day activities to make sure that they have the correct amount of resources (e.g. employees) during the day. Lastly, *Capacity of the terminal* is important to know such that they can inform others if the terminal can't receive any more goods. This can happen if there are production issues, resulting in material not being consumed at a normal pace. Eventually, if no material is consumed and new material flows in, the physical storage space at the container yard will run out.

Transport Coordination (Plant C)

Transport Coordination at Plant C has the same information attributes as Logistics Operations at Plant A with the exception that *Time of delivery* is not of great importance for Transport Coordination. As their main role is to load the train with the material needed at the main production plants *Train ID*, *Wagon ID*, *Container ID* and *ETA* are important in order to get an overview of the trains and their contents. Furthermore, Transport Coordination prefer more accurate *ETA* rather than a quick estimation since their planning is dependent on the *ETA* received.

Deviation Information affects how Transport Coordination plan upcoming deliveries, both from a scheduling perspective but also regarding what material to load onto the trains. Since Plant C require the packaging material to return in order to send new material, deviations will have an impact on their planned schedule and the overall flow. *Goods priority information* is used by Transport Coordination to plan what material to put on the train and whether an express delivery is required. Finally, if an *Alternative route* is used, Transport Coordination needs this information since it usually causes longer lead times, which affects their planned schedule. Sometimes re-routes are planned way ahead and sometimes they appear with short notice.

Terminal Operations (Plant C)

Terminal Operations at Plant C need the same information attributes as Terminal Operations at Plant A. However, at Plant C they do not have an issue with the capacity of their terminals. Plant C uses *Train ID*, *Wagon ID* and *Container ID* to ensure that the correct material is loaded into each container and that each container is loaded onto the correct train. Since Plant C is responsible for what material goes into each container it is crucial that this information is correctly communicated

between Transport Coordination and Terminal Operations. The remaining information attributes are used in the same manner as Terminal Operations at Plant A described above.

Plant B

The most crucial information attribute for Plant B is *Container ID*. Since Plant B is working closely with the 3PL regarding the handling of the containers it is very important for Plant B to identify what containers are unloaded from the train and ready for pick up, and what containers have been delivered to Plant B. Furthermore, *Deviation information* is also important for Plant B since their production is reliant on the material from the train. However, with the current setup, the 3PL container yard works as a buffer where they have a safety stock of approximately 24 hours. This reduces the risk delayed trains, which in turn slightly lowers the importance of *Deviation information*, even though it is still very important. *Deviation information* is also necessary to ensure that resources are used efficiently and it helps with planning activities in the same manner as for Terminal Operations at the other plants. Lastly, Plant B uses *Goods priority information* to communicate with the other actors which containers needs to be prioritized.

Train Operator A & Train Operator B

Train Operator A and Train Operator B has the same list of information attributes since their activities are similar and they are cooperating during the process of transporting the trains. Therefore, the information attributes will be described in reference to both of them and they will be referred to as Train Operators throughout this section.

First off, *Train Status* is of major importance to the Train Operators in order to ensure that the transportation process is running according to schedule. *Train ID* is used for communicating the status updates further down the chain to the actors affected. *Wagon ID* is used to keep track on the wagons used during transportation. *Container ID* is used to identify how many containers are included in each shipment, to verify that each container has been delivered according to plan and to communicate with other actors if any complications has occurred with a specific container. Moreover, *ETA* and *Deviation information* is closely linked. *Deviation information* is used to inform other actors if and why a deviation has occurred while *ETA* is updated to match the deviation.

To schedule their activities and resources, the Train Operators uses *Estimated pick-up time*. They also have access to *Position* information, which is useful if they need an update on the train position and are unable to communicate with the train driver. The Train Operators also require a *Bill of lading* to know the contents of the containers and that it follows regulations and weight limitations. It also acts as an agreement of the transport between them and the sender. In addition to this, *Invoicing* information is crucial to ensure correct payments for the train transportation process.

Driving times for the driver is mostly critical for the international flow where the transportation takes longer time and driver swaps are scheduled at different check points. To ensure that the train can go on without delays, it is important for the Train Operators to schedule and coordinate their driver swaps to ensure that the train does not end up at a check-point where the driver needs to take a long break causing a delay. *Breaking status* is also most important for the international flow in case there are any issues with finding replacement for drivers, where a driver's break must be monitored to know how the ETA is affected.

Furthermore, *Queuing status* is important for the Train Operators due to the deviations that might be the result from these queues. However, the queues in the terminals/hubs might be something that the Train Operators cannot affect. Finally, *Alternative route* is used when there are obstacles on the routes that are severe to the extent that an alternative route is necessary. The Train Operators then communicate this information to the concerned actors.

3PL

The 3PL currently have access to *Train ID*, *Wagon ID*, *Container ID*, *ETA*, *Deviation information*, *Estimated pick-up time*, *bill of lading* and *Time of delivery*. The 3PL uses *Train ID* to track what train is arriving at their container yard and *ETA* to know at what time. *Train ID* is also used to update Plant B with information regarding the unloading process. *Wagon ID* is used to load the correct container on the correct wagon as well as identify a specific container placed on a wagon. *Container ID* is used when communicating with Plant B regarding what containers to shunt into the assembly plant. Furthermore, the *Container ID* is used in order to plan how the containers are arranged in the container yard.

Deviation information is used to re-plan resources and activities in case the train does not arrive on schedule. *Estimated pick-up time* is used for knowing when the train is supposed to leave the yard for the return route back to Plant C. The 3PL must ensure that the train leaves on time since the flow is complex and time-critical, where a small deviation can cause bottlenecks. A *Bill of lading* is received from Plant C with the information regarding each container.

4.2.3 Desired information attributes

During the interviews it became evident that some actors wanted access to information attributes that they did not currently have access to in order to improve their activities. It was decided to refer to these as desired information attributes. Many of the desired information attributes mentioned exist among certain actors, but are not in access by the actor who highlighted their desire for it. Other desired information attributes exist in some shape or form, but have to be modified and molded such that they would fit the TMS structure. Table 4 contains all the desired information attributes identified from the interviews, many of which were also identified through the literature review. A more detailed list including descriptions and references of the desired information attributes can be found in Appendix C.

Table 4: An overview of the identified desired information attributes for each actor

Actor	Information attributes
Logistics Operations (Plant A)	Train status, Sequence direction of train wagons, Actual time of delivery
Optimization (Plant A)	Train status, Bill of lading, Container fill rate, Emissions
Terminal Operations (Plant A)	Train status
Plant B	Position
Transport Coordination (Plant C)	Train status, Position
Terminal Operations (Plant C)	Train status
Train Operator A	N/A
Train Operator B	N/A
3PL	Train status, Goods priority information, Alternative route

Logistics Operations (Plant A)

Logistics Operations at Plant A currently receives *Train status* updates when a deviation report is sent via email. They would therefore like to receive this information in the TMS instead such that they can regularly monitor ongoing transportations and have access to the information through a system rather than to be dependent on email send outs. They would also like to include check-points to the *Train status* attribute. This means that the within the *Trains status* attribute, certain check-points would be set along each of the two routes and then updated as the train passes a check-point. This allows the actors to get a better understanding of its position without having to use real-time GPS data.

Since the containers on the train only can be unloaded from one side at the Plant A terminal, it is ideal to know the *Sequence direction of train wagons* such that Logistics Operations can communicate to the train operator that the train needs to be flipped before arriving at the terminal. This would prevent unloading delays at the terminal. Having easy access to *Actual time of delivery* would allow Logistics Operations to foresee any complications for upcoming transportations if this time stamp does not match the scheduled time of delivery.

Optimization (Plant A)

Optimization at Plant A would benefit from having historical data of *Train status* updates with time stamps since they need to understand what parts of the flow could be optimized. Today this information needs to be manually extracted from multiple emails, which demands manual labor and is limited to the deviation reports. Both *Bill of lading* and *Container fill rate* can be used to optimize the fill rate of containers and the entire train and are therefore of interest to the optimization team. Lastly, *Emissions* information would be beneficial for the optimization team to evaluate how they can improve the environmental footprint of the rail freight network.

Terminal Operators (Plant A & Plant C)

Terminal Operators of both Plant A and Plant C desire *Train status* so that they can monitor the train progress and schedule resources for unloading and loading the train accordingly.

Transport Coordination (Plant C)

Transport Coordination at Plant C desire *Train status* in order to schedule the upcoming train transports with the latest information on incoming transportations. The *Position* attribute would help Transport Coordination with their decision-making regarding express delivery bookings in cases where a train is delayed.

Plant B

Plant B desires *Position* of specific containers in order to better trace when containers are unloaded from the train, in transit on the 3PL yard and what containers are available for pick-up. This would allow them to more efficiently know what material can be shunted from the container yard to the assembly plant.

3PL

For the same reason as most of the actors, the 3PL also desires *Train status* updates in order to monitor the incoming transportations. Since the 3PL use their container yard for storing containers for Plant B, they would also benefit from having *Goods priority information* because it would enable a more efficient container storage system since they would know if any containers should be prioritized.

4.2.4 Evaluation of the information attributes

The following section describe how the information attributes were evaluated and classified in order to differentiate the necessary information attributes for a successful TMS implementation from those that could be integrated at a later stage.

4.2.4.1 Review of the information attributes

The list of information attributes presented in Section 4.2.2 was based on the interviews conducted in the data collection process. To ensure that no important information attribute was missing, a literature review was conducted where relevant information attributes was added to the list. The complete list of all information attributes gathered from interviews and literature was then presented to a focus group with the aim to construct a final list of information attributes where every important information attribute was included. One of the outcomes from the focus group meeting was to add the following information attributes to the list: *Actual time of departure* and *ETD (Estimated time of departure)*. *Actual time of departure* is important to include such that delays can be predicted in an early step of the process. Additionally, when there are any deviations from the original scheduled departure time, *ETD* can provide an estimate of when the train will depart, which enables planning for future events.

Furthermore, four changes were made to the information attributes in discussion with the focus group. Firstly, *Alternative route* and *Sequence direction of train wagons* was combined into one attribute since they are both directly linked to the fact that each time the train wagons are not arranged in the correct order and direction it is because an alternative route has been taken. This is because the train wagons

change direction each time a locomotive switch occurs. During the normal routes, the correct amount of switches takes place for the train wagons to be in the correct direction when it arrives to the plant terminal. However, if an alternative route has been taken, an additional locomotive exchange may be necessary, which causes the train wagons to arrive in the wrong sequence direction. Therefore, this information attribute was renamed *Reversed train direction*.

Secondly, *Time of delivery* and *Estimated pick-up time* were also combined and renamed *Tactical Window* due to that being the terminology used at Volvo Cars. *Tactical window* now refers to the planned time frame for both pick-up and delivery. Thirdly, during the focus group meeting, the information attribute *Capacity of terminal* was deemed more impactful if it included status updates of not only the terminals but all of the check-points throughout the flow. It was therefore combined with *Train status* and renamed *Train status 2.0*.

Thirdly, *Container fill rate* was modified since the information attribute was focusing on the fill rate of individual containers. During the meeting it was concluded that information regarding the fill rate of each container was not necessary but rather the fill rate of the entire train. The information attribute was therefore renamed *Train fill rate* and now refers how many containers are loaded onto a train.

Lastly, given that *Driving times for the driver*, *Breaking status* and *Queuing status* are the responsibility of the train operators it was decided to include this within the *Deviation information* attribute. A final list of all information attributes including the changes described above can be seen in Table 5.

Table 5: *Updated list of information attributes*

Information attributes	
Train ID	Bill of lading
Wagon ID	Invoicing
Container ID	Train fill rate
Deviation information	Tactical window
Goods priority information	Actual time of delivery
Position	Actual time of departure
Emissions	Reverse train direction
ETA	Train status
ETD	Train status 2.0

4.2.4.2 Classification of information attributes

With an updated list of information attributes, the next step as explain in Section 3.3.1, was to classify the attributes based on their necessity to the implementation. In discussion with the first focus group, it was decided that the information attributes was classified depending on whether the information attribute is a "Must have", referring to information attributes critical for the implementation and "Nice to have", referring to information attributes that is important but could be imple-

mented in a later stage of the processes. The use of this terminology was decided together with the focus group since this is the terminology that Volvo Cars use in-house. A list of the final classifications is displayed in Table 6.

Table 6: *Classification of information attributes*

Information attributes	
<i>"Must haves"</i>	<i>"Nice to haves"</i>
Train ID	Emissions
Wagon ID	Train fill rate
Container ID	Goods priority information
Train status	Position
Deviation information	Invoicing
Bill of lading	Reverse train direction
ETD	Train status 2.0
ETA	
Actual time of delivery	
Actual time of departure	
Tactical window	

The information attributes considered "Must haves" are either technical requirements of the system, a legal requirement or have a critical impact to the train transportation process. *Train ID*, *Wagon ID* and *Container ID* are required to have complete traceability of the material transported and facilitates all the other information attributes. *Bill of lading* is a legal document required for each container deemed a "Must have". *ETD*, *ETA*, *Tactical window*, *Deviation information*, *Actual time of delivery and departure* and *Train status* were classified as "Must haves" since they are necessary to keep the train operations running.

The remaining information attributes based on the updated list (see Table ...) were classified as "Nice to have" since they were neither technical system requirements, legal obligations nor considered to have a critical impact to the overall operation of the rail freight network.

4.2.4.3 Ranking of "Nice to have" information attributes

To further evaluate the "Nice to have" information attributes they were all ranked. As described in Section 3.3.1, the ranking was used to identify in which order Volvo Cars should implement the "Nice to have" information attributes at the second phase of implementation. Table 7 provides a list of the ranked "Nice to have" information attributes where the highest scoring attribute should be the first one to focus on during the second phase of implementation and then the list should be followed from highest to lowest score.

Using the Best-worst method (BWM) requires weighing each criteria against each other regarding the weight of the criteria. The weight of each criteria was calculated with the help of the first focus group meeting and the result can be seen in Figure 4.

Together the three criteria weights adds up to 100 % as can be seen in the Figure. A description as well as the choice behind each criteria can be seen in Section 3.1.2

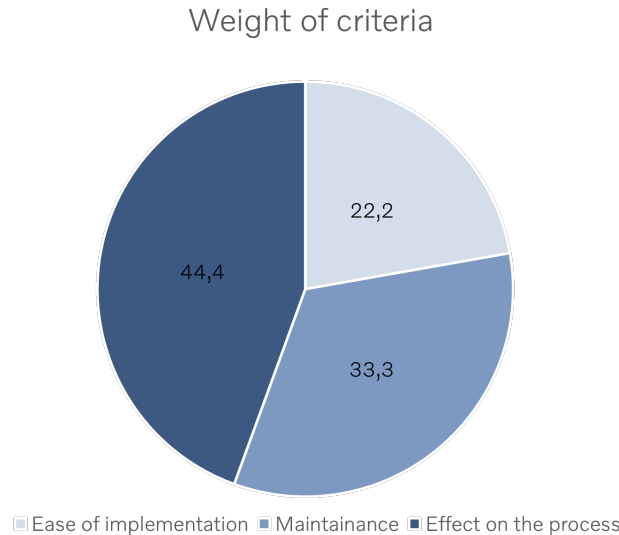


Figure 4: Pie chart of the weighted criteria

The results of the weighted criteria show that *Effect on the process* is the most important criteria with a contribution of 44,4 %. Given that the purpose of the TMS implementation is to gain long-term advantages it makes sense that this criteria is the most influential. *Maintenance* is the second most important criteria with a weight of 33,3 %. The reasoning behind this weight is that if the information attributes are costly, time-consuming and difficult to both utilize and maintain the actors would probably not bother using and updating them. This would mean that their potential benefits could be lost and therefore the effort of implementing them is wasted. Finally, *Ease of implementation* is considered the least important criteria with a contribution of 22,2 %. Since Volvo Cars has a long-term vision towards improvements, an implementation is a one time cost compared to all the savings that could be generated in the long-term. Because of this, even though the ease of implementation is important, it is not as important as the other two criteria.

When the weights of the criteria had been decided, the BWM requires a ranking of criteria in reference to each information attribute. A ranking scale of 1-5 was used as explained in Section 3.1.2. This initial ranking was based on the information provided from interviews as well as the first focus group meeting and the results of the ranking can be seen in the Table 7 below:

Table 7: *Ranking of "Nice to have" information attributes*

Information attribute	Ease of implementation	Maintenance	Effect on the process	Total
Train fill rate	4	4	4	4,00
Emissions	3	5	3	3,67
Reverse train direction	2	4	4	3,56
Goods priority list	4	4	3	3,56
Invoicing	3	4	2	2,89
Train status 2.0	2	2	4	2,89
Position	2	3	3	2,78

As explained in Section 3.3.1 a survey was also used to compare the results of the BWM in order to see if they differ from the subjective ranking of the employees selected for the survey. The survey contained two parts where the first part allowed each respondent to pick up to four out of seven "Nice to have" information attributes that they considered to be important. For the second part the respondents had the opportunity to rank their choices from 1 to 4 in terms of order of priority as well as provide an explanation behind their decisions. The result of the survey can be seen in Figure 5.

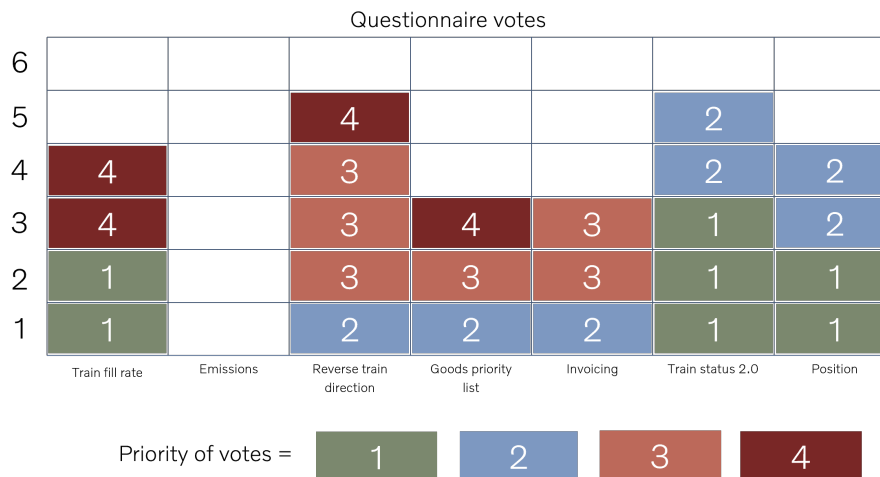


Figure 5: Result from "Nice to have" questionnaire

The figure illustrates the answers collected from the survey where each vote is color-coded. A green '1' indicates first priority and a blue '2' indicates second priority and so on. The y-axis visualises the number of votes each information attribute received and the x-axis displays the seven "Nice to have" information attributes used in the survey. Since The respondents were able to rank up to four information attributes from 1 to 4 the figure illustrates their choices. For example, *Train fill rate* received a '1' from two respondents and a '4' from two respondents, which means that four respondent chose that information attribute as important and two of them put it as the highest priority and the other two as the fourth highest priority.

As can be seen in Figure 5, *Train status 2.0* and *Reverse train direction* received the most votes, both with a total of 5 votes. However, its evident that the priority of

Train status 2.0 is greater than *Reverse train direction* since it was considered the highest or second highest priority from all respondents who voted for it. Furthermore, *Emissions* scored poorly since it did not receive a single vote. Taking both the vote priority and the number of votes into consideration the survey provided the following ranking order where '1.' is the most important and '7.' is the least important; 1. *Train status 2.0*, 2. *Position*, 3. *Reverse train direction*, 4. *Train fill rate*, 5. *Invoicing*, 6. *Goods priority information* and 7. *Emissions*. A comparison between the ranking made from the BWM and the survey will be made and discussed in Section 5.4.

4.3 Findings related to RQ3: Potential effects

This section describes the potential effects of a TMS implementing to the rail freight network based on the data collected from the interviews. Because these are findings from the interviews conducted they are hypothetical and subject to change once the implementation occurs.

The results presented in the subsections below are categorized using the model for implementation evaluation presented in Section 3.1.3. The data collection provided a clear distinction of the potential effects, one affecting operational aspects and the other strategic aspects and that they should be viewed separately. The results have therefore been divided into operational and strategic effects.

4.3.1 Potential operational effects of the TMS implementation

It is evident that there are both positive and negative operational effects of implementing a TMS system to the rail freight network. The operational effects have therefore been divided into positive and negative effects according to the model for implementation evaluation.

4.3.1.1 Positive operational effects

The positive operational effects are divided into three sections based on the model for implementation evaluation. The sections include *Decision-making benefits*, *Communication and coordination improvements* and *Organizational competitiveness* as seen below.

Decision-making benefits

First off, the TMS in question has an integrated function for financial transactions which could be used to automate the billing process for all train transportations made. This would speed up the payment process to the train operators and reduce decision-making, which could provide cost-savings. Moreover, since financial transactions are currently done manually, having an automated billing process could also reduce the risk of human errors. An example of a human error could be paying a train operator the wrong amount, either too much or too little. Another benefit of using the automated billing function is therefore that it could increase the reliability of payments. Finally, the fact that the TMS stores data for each transportation made could be used as accurate evidence for payments, reducing the risk of any

financial disputes.

Secondly, the use of a single integrated system for the entire rail freight network would reduce the risk of untimely communication, misunderstandings between actors and improve deviation responsiveness. These aspects could enhance operational decision-making, save money and reduce overall costs for the organization.

Lastly, the interviews identified that having real-time updates of the trains location and status would be beneficial for time sensitive decision-making. One example stated by Transport Coordination at Plant C was that they are responsible for booking express deliveries as a back up solution if a train is delayed. However, as the express deliveries are costly they need to ensure that the express delivery will arrive before the train and therefore justify the cost. Since this decision require fast decision-making, having real-time information of the trains location and status would provide Transport Coordination with more accurate and easily accessible data to base their decisions on. This could therefore avoid unnecessary expenses.

Communication and coordination improvements

With the use of an automated billing function, coordination of financial transactions are likely to improve as human involvement is reduced. This would mean that transactions should be conducted much faster and train operators should receive their payments more smoothly. Since the process is automated and based on data within the system, it is also likely to reduce communication needed between the actors since the financial transactions should become more accurate and consistent, which reduces the need for communication overall.

Another potential benefit is that the communication flow could become more coherent using one system across all actors to communicate information and deviations. As mentioned in section 4.2.1, there are currently different train IDs used along the routes which causes confusion during communication. Moreover, as discussed above, real-time updates through the system would not only improve decision-making, but it could also improve communication. The information would reach the concerned actor much faster as the added delay of manual communication is eliminated. As a result, actors such as Transport Coordination at Plant C would be able to coordinate activities more efficiently.

Organizational competitiveness

Using the automated billing function would advance Volvo Cars's operational working process as it would free up time and resources involved with manually handling financial transactions. This could therefore be seen as something that enhances Volvo Cars's competitive advantage. Based on the same arguments, having an integrated system for communication between the actors within the train process could also be argued to increase the organizational competitiveness of the company.

4.3.1.2 Negative operational effects

The negative operational effects are divided into four sections based on the model

for implementation evaluation. The sections include *Technical issues*, *Human issues*, *Organizational structure* and *Economic limitations* as seen below.

Technical issues

One of the main obstacles regarding this implementation is the creation of orders in the system. This could cause technical difficulties since the current setup does not support an easy transition into the TMS. There is currently a lack of technical capability to automate the order creation for example. Another obstacle is the low level of digitalization used in the flows today. This once again relates to the lack of technical resources of the train process and poses a challenge regarding what activities of the process should continue to be performed manually versus what can or should be automated. Moreover, actors such as the 3PL insist on using their own TMS, which means that the new TMS has to be linked to their TMS, which is a technical challenge that needs to be conquered.

Human issues

Much of the negative effects that have been addressed are the operational risks of changing the current way of work and that it might create a heavy workload for those actors who are not familiar with working with Volvo Cars's TMS. There is also shown concern towards adding a new system to the rail freight network and having to learn that system. Some actors are sceptical towards this because they have previous experience of system changes where the outcome resulted in several issues and challenges in the early stages of the implementation. Similarly, the 3PL expressed a concern regarding how the implementation of an additional system would force them to have to deal with this additional system. Since they already use an efficient TMS, having to use another one is not ideal from their perspective unless the two systems could be linked automatically.

Another human-related concern is how the TMS implementation would affect Transport Coordination at Plant C. As they already have a high workload regarding the train transportations it is ideal that as much of the integration as possible is automated. Otherwise there is a risk of overloading this department with additional tasks. Train operator A has also expressed a similar concern. They want to avoid additional manual labour, which means that the digital tools within the rail freight network needs to advance. On top of this, they are not familiar with the TMS in use by Volvo Cars, meaning that they also have to be taught how to use and communicate with the system, which could be seen as another obstacle.

Organizational infrastructure

Current procedures within the rail freight network are likely to change since a TMS implementation would result in a large technical upgrade. Therefore, the implementation will most likely redistribute responsibilities and adjust how activities are conducted. Having to change current organizational procedures are not always an easy task and this is therefore viewed as a potential limitation of the implementation.

Economic limitations

Given that the order creation has to be automated and that Volvo Cars currently does not have the technical capability to do so there are expenses linked towards this part of the implementation. The magnitude of these expenses are unclear as this goes beyond the scope of this report, but it is clear that Volvo Cars has to invest resources in order to get the order creation to function properly. Additionally, linking Volvo Cars's TMS with the TMS used and developed by the 3PL is likely to add to the economic cost of implementation.

4.3.2 Potential strategic effects of TMS implementation

Similar to the potential operational effects of the TMS implementation, there are both positive and negative strategic effects that could occur. These effects have also been divided in accordance with the model for implementation evaluation.

4.3.2.1 Positive strategic effects

Similar to the positive operational effects, the positive strategic effects have been divided into three sections according to the model for implementation evaluation as seen below.

Decision-making benefits

One of the main drivers for this thesis was the fact that Volvo Cars wanted to have more information and better understanding of their train transportation operations. Implementing the TMS would greatly increase their capability to gather historical data and more easily extract the data and analyze it in order to work with improvements. Firstly, the optimization team in Plant A would greatly improve their efficiency since they could, with the TMS, get access to the data that could be used to improve their understanding of the train transportations. Some of their KPI:s such as Co2 emissions and train fill rate could more easily be tracked and managed with access to data through a TMS. The use of a TMS would also enable a more detailed deviation analysis of different segments of the routes, which would help them identify what parts of the flow need development in order to improve the overall flow.

The currently used to assess the performance of the train operators is manually extracted from the deviation reports that has been sent to Volvo Cars during the weeks leading up to the performance review meeting. Using a TMS would enable them to instead generate their own data and therefore be able to extract much more details regarding their operations. Train Operator A further stated that a TMS implementation would allow them to better generate information in regards to the KPI:s they are tracing. For example, they currently handle their KPI:s manually, but a TMS would allow some of this process to be automated, which would save them valuable time. Both Plant C and Plant B have also stated that the possibility to generate historical data regarding the flow would increase their understanding of the flow and enable them to work with improvements.

Communication and coordination improvements

Being able to access more data and in a structural manner would facilitate optimization work. Optimizing the rail freight network is therefore likely to improve both communication and coordination within the process. The accessibility of the historical data in the TMS would also benefit the cooperation between Logistics Operations at Plant A and Train operator A. They are working closely together in order to improve the flow through check up meetings and tracing KPI:s, and with the additional information that would be accessible through the TMS it would improve their efforts to understand what needs to change for overall improvement. Additionally, as performance evaluation of the train operators is likely to enhance through the implementation, the coordination would also improve as a result. This is because Volvo Cars could help the train operators identify what parts of the process that needs improvement.

Organizational competitiveness

Improving the decision-making process through the TMS implementation as well as providing access to more data that could be used for optimization would help Volvo Cars improve KPI:s and optimize the overall process. These aspects are likely to improve the overall organizational competitiveness. Moreover, it was stated during the interviews that having implemented a TMS for the rail freight network would ease future potential expansions of the network. Therefore, by implementing the TMS and improving the process benefits Volvo Cars in the long-run when additional actors may be added to the flow. Generally, the more actors that are involved in a transportation network, the more complex it will become. Therefore, having the correct processes in place before the new plant is included allows more risks to be mitigated in regards to the transportations made. Working with improving the train process would therefore not only make current train transportation routes more efficient, but it also provides a solid foundation for upcoming train solutions.

4.3.2.2 Negative strategic effects

The data collection provided few negative strategic effects of the implementation. However, a lightly stated concern was that if any of the actors involved in the rail freight network would refuse to work with the system before or after the implementation, replacements would have to be made. However, replacing an actor is not a simple task and would involve lots of time and money. The new actor does not only have to be identified and verified. They would also have to learn how to use the new system and learn about the entire process of the rail freight network. This obstacle could be linked to all of the limitations of implementation from the model of implementation evaluation (see Section 3.1.3).

Another strategic issue that the TMS implementation could cause is that organizational policies and procedures has to be reworked for the train process. For example, road transportations who currently operate in relation to the TMS follows a certain amount of internal policies and procedures. Due to the characteristics of the rail freight network it was expressed that these policies and procedures may

have to be reworked in order to fit the TMS since the current train set up would not match. This can be primarily linked to limitations of the organizational infrastructure as well as economic limitations through the perspective of the model for implementation evaluation.

5 Analysis

The following chapter aims to analyze the empirical findings presented in the previous chapter using the frame of reference. The chapter has been divided into two sections where the first section is aimed towards RQ1 and RQ3 and the other towards RQ2 and RQ3. RQ3 is included in both sections since it encompasses the bigger part of this chapter.

5.1 Analysis related to RQ1 and RQ3: Actors, resources, activities and potential effects

This first section of the chapter aims to analyze the empirical findings in relation to both RQ1 and RQ3. It involves analyzing the complexities and obstacles related to the rail freight network and how to overcome them, the technologies in use and the benefits of using a TMS.

5.1.1 The complexity of the rail freight network

Based on the empirical findings it is evident that the international route is significantly more complex than the domestic route. Some of the reasons include longer route, numerous exchange locations, more drivers included and additional actors involved. Other complexities are the structure of the rail freight network and the current flow of material. These complexities are discussed and analyzed below.

Characteristics of rail freight

The large amount of actors identified in Volvo Cars' rail freight network is highlighted by Hegedus et al. (2018) as a characteristics of rail freight. Some of the complexities that follow could therefore be argued to not be specific to this case, but rather a reflection of the characteristics of rail freight. It is also apparent that the international route is affected by governmental regulation as mentioned by Amos (2009). For example, during the international route, the driver has to be switched at many of the boarder-crossings since their drivers licence is only valid within their nation of origin or for a specific region. In other words, the fact that train driver licenses are not international, forces the train to stop many times more than necessary, which is both time consuming, costly and an additional factor that could cause issues during rail freight. Another boarder-crossing concern expressed by Szkoda (2014) is the non-standardized rail gauge. This is however not an issue along the international route as the railway track used has the same rail gauge throughout the route. With this said, Volvo Cars aims to increase train transportation since the due to the sustainable aspects of the transport mode. Increasing rail transportation is aligned with the current sustainability trends originating from the Paris Agreement to reduce GHG emissions and the EUs targets to double the share of rail freight by 2030 (United Nations, 2015; Rail Freight Forward, 2020).

The current structure of Volvo Cars' rail freight operations

Given that Plant A is the main plant and that the business is centralized around

this actor the importance of sharing information between actors is crucial to enable fast and accurate decision making regarding the logistical operations throughout the organization. The structure of Volvo Cars' logistic operations is referred to as concentrated by Abrahamsson et al. (2003). Since the decision-making body is not directly connected to the operations, the information needed must be quickly transferred as well as relevant to the operations. Evidence of missing information was discovered during the data collection process and therefore, a successful implementation of the TMS, will provide benefits to the centralized structure of Volvo Cars. In addition to this, the decision-making based in Plant A craves a universal identification system for the train process today is decentralized resulting in multiple different identification numbers for the same train. Using the TMS as the central communication channel will eliminate any risk of misinterpretation during information exchange. This includes inconsistencies such as the use of different Train IDs. Furthermore, matching the communication channel with the centralized structure of Volvo Cars will, according to Abrahamsson et al. (2003), increase the flexibility of the organization to deal with external uncertainties. The implementation of a centralized TMS will not only generate information that enables fast decision-making for Plant A but also provide more information to all other actors involved in the network. These actors will then be able to develop, improve and optimize their process aligned with the entire network.

The uneven flow of the international route

Given that the international flow is not a one-to-one flow, certain issues arise. First of all, the uneven flow results in more containers with material arriving to Plant B than what is consumed from manufacturing. This is because the weekend transportations are stored and not used for production straight away since the production plant is not running. Secondly, since there is no system in place for returning packaging material, Plant C can either receive less packaging material than was originally sent or the wrong selection of packing material types. Either way, the consequence could be that Plant C run out of packaging material. Without the correct type of packaging material in possession, new material cannot be loaded, which in turn would cause a material shortage at manufacturing Plant B. This needs to be avoided at all costs as it is very expensive to not keep production running. Since Plant A and Plant B use different types of packaging material, the international route cannot borrow packaging material from the domestic route, which means that the international route is vulnerable in regards to its return flow.

5.1.2 Obstacles to overcome for a successful TMS implementation

In order to achieve a successful implementation of the TMS, there are certain obstacles that needs to be discussed. The following section analyze these obstacles as well as discuss the potential effects that a successful TMS implementation could yield.

The challenge of standardizing the implementation process

One of the goals with the implementation is to add check-points for the train at all current stops or exchange points along the two routes. Since there is a large difference in the amount of stops between the domestic and the international route,

the implementation process has to take this into consideration. As the two flows are not standardized themselves, the challenge is to standardize the implementation of the two routes, considering that this could lead to substantial cost savings as well as increased maintainability and reliability (Ross, 2003). Given that the TMS will be used on a daily basis by several actors, the mentioned possible outcomes are of significance.

Unequal motivation between actors towards the TMS implementation

Further complications arise from the fact that some actors within the train process are internal and others are external. This means that the external actors, such as the train operators and the 3PL are more keen on developing their own processes rather than helping Volvo Cars develop theirs. For example, since Volvo Cars is simply a client to the 3PL, they have developed their own TMS which could be used for all of their clients, which means that their incentive towards improving Volvo Cars's train process is rather low. This relates to the discussion made by Buijs and Wortmann (2014) who discuss how not having an integrated IT-system hinder joint optimization, where optimization work is limited within the boundaries of each actor. Moreover, as the various actors use different systems, some of the actors are unfamiliar with the TMS that Volvo Cars use. This adds to the complexity because it prevents Volvo Cars from simply focusing on developing and improving of the train process through the TMS implementation, but also forces them to both convince the actors unfamiliar with the TMS to agree upon working with the system as well as teaching them how to use it. As the study by Godkin and Allcorn (2008) states, in order to overcome these internal barriers of change, communicating the value of this implementation becomes extremely important. All actors affected needs to understand the value of the implementation to ensure that actors are motivated to contribute towards the new way of working.

The implication of irregular transportation content

The fact that only 80% of containers are filled with predetermined product mixes also complicates the implementation process since order creation cannot be standardized based on the product mixes. In an ideal world, this 20% would not be necessary and therefore the goal is to minimize this amount since it would ease order creation, loading and unloading times and improve overall cargo knowledge. However, this is a challenging process and not something that will be complete in a short-time period, which is why the 20% of randomized pallet goods has to be taken into account when implementing the train routes with the TMS.

5.1.3 Use of technology within the rail freight network

The use of technology is a crucial part for efficient logistics operations. With this said, the findings from this study showed a varying degree of technologies in use. The section below analyzes the drawbacks of the current technological situation as well as the potential positive outcomes a technology advancement could provide.

Volvo's current level of technology use

Volvo Cars are currently using phone and email as a primary means of communica-

tion for the train process, which Perego et al. (2011) describes as a low level of ICT adoption. According to Perego et al. (2011), a company the size of Volvo Cars needs to have a higher degree of ICT adoption since this improvement can increase both operational efficiency and effectiveness. The benefits of using a sophisticated system as discussed by Kia et al. (2000) can also help Volvo Cars optimize the train process and support terminal operations.

Berrios Villalba (2020) discuss how there is a lack of digitalization and use of modern technology within the rail freight sector, which is reflected in this case of Volvo Cars. Given that Volvo Cars uses phone calls and emails as a primary source of track and trace as well as overall communication in regards to the train operations, a technology upgrade is long overdue. The most probable reason for why Volvo Cars has not upgraded their use of technology in connection with the train process would be the convenience of using a method that simply works. The current method used is good enough to keep the operations running and therefore no effort has been put towards improving the process until now. This aligns with the reasons addressed by Berrios Villalba (2020) regarding why companies does not increase their use of digital resources. However, systems that are good enough does not provide longevity in a competitive industry such as the automotive industry, which is why all aspects of the operations needs to improve along with the state of technology, such that the benefits that it provides can be yielded. This has been emphasized by Marinov and Viegas (2011) among others, who discuss that implementing more advanced technology could provide a more structured network, which in turn would improve Volvo Cars's rail operations overall.

The many different systems used within the rail freight network

A plausible but not fully confirmed reason for why a more sophisticated system has yet been introduced to oversee Volvo Cars's train process could be due to that many of the actors involved already utilizes their own internal systems. For example, Plant C uses SAP and the 3PL uses their own TMS. This enlarges the challenge involved of getting all the information related to the train process under one roof, which according to Buijs and Wortmann (2014) is ideal since they list several drawbacks of not having an integrated IT-system. Nettsträter et al. (2015) states that the reason for why a TMS exists is due to the the growing complexity of transportation networks, where an enormous amount of information is shared throughout the network which is becoming more and more difficult to process without the use of a TMS. In other words, not using a TMS could reduce the overall transportation quality in the long run. Buijs and Wortmann (2014) also discuss how simply connecting one TMS with another is not enough, but rather that the TMS needs to be connected to other types of systems in order to make it more sophisticated.

Given that the Volvo Cars's rail freight network involves several different types of system, the statement by Buijs and Wortmann (2014) seems to turn something that could initially be seen as something complex and therefore negative into something more positive. Based on this, having a common TMS seems to be an appropriate course of action, even though there are barriers in place complicating such a deci-

sion. Using a centralized TMS also aligns with the previous discussion in relation to Abrahamsson et al. (2003), where a centralized TMS makes sense given that the logistics operations are centralized around Plant A. This could in turn create a synergy in the long-run between the TMS and the logistics operations since all actors have access to the information in an identical format, improving the communication structure and preventing certain information from getting lost along the way. Buijs and Wortmann (2014) further suggests that having a single unit TMS could contribute towards a collaborative effort of optimization among the actors.

The issues of manual information exchange

The drawbacks of using email and phone calls as a source of communication is that information sharing occurs manually. This could cause several issues. First of all, the information exchange is not instant, meaning that there is a certain time added between when the sender notices something that needs to be communicated to the other actors until the information is finally sent. There is also a risk of an email not reaching the correct actor or the reaching the receiver at all, which could either be the cause of a human-error, where the wrong email-address was used or a syncing error of the mail-service provider used. In addition to this, the email could get lost in the inbox of the receiver and unless the sender specifically asks the receiver to reply to the email, the sender has no way of knowing that the information sent was read by the receiver.

The advantages of using an IT-system as a source of communication

To update all actors regarding the train process through manual labour is a time-consuming process. It is therefore ideal to reduce manual labour by introducing an IT-system. This can be associated with the argument by Rainer and Prince (2021) who suggests that reducing manual labour through an IT-system can increase employee autonomy and flexibility. O'Brien and Marakas (2006) further explain how an IT-system is ideal for logistics operations with multiple actors, which is the case of Volvo Cars's train process. O'Brien and Marakas (2006) further explain how an IT-system overcomes the complexity of sharing precise and real time information with numerous actors at once. In other words, by using an IT-system, Volvo Cars could reduce the majority of issues discussed regarding their manual methods of information exchange. This further aligns with Rainer and Prince (2021) who state that IT-systems help reduce dull manual labour, but also that it increases visibility. Using an IT-system could therefore for example allow Plant C to more accurately book express deliveries if deviation information could be accessed through an IT-system that is automatically updated, since this increases visibility as well as eliminates manual delay and the risk of human-error issues. As bookings of express deliveries with trucks are both costly and time-sensitive, the outcome of using a sophisticated IT-system could provide Volvo Cars with significant benefits in terms of cost-savings.

Increased optimization ability through the use of a TMS

One of the main reasons for why Volvo Cars management wants to implement the train process in their TMS is such that they can collect and extract valuable data that can later be used to optimize train operations as well as contribute towards

decision-making. This aligns with O'brien and Marakas (2006) who states that an IT-system can provide management with correct and up-to-date information, which is crucial for decision-making. With a larger amount of easily accessible data, Volvo Cars could use the information to identify bottlenecks in the transportation flow, find patterns and analyze why certain events occur at certain locations or points in time along each train route. Similar to what Rainer and Prince (2021) argue, this enhances work efficiency of the optimization team and improves managers ability to quickly take appropriate actions. This is in turn backed up by arguments made by Nettsträter et al. (2015).

Improved performance reviews through the use of a TMS

To help evaluate and enhance the train transportation flow, it is necessary that Volvo Cars conducts performance reviews of the train operators used. Much of the performance evaluation is based on deviation reports. As Volvo Cars currently receives deviation reports through an email for each case of a deviation it is a challenging and time-consuming process of compiling all the information from the large amounts of emails received to get a holistic view of the train operators' overall performance. By instead having all this historic data in a single system would first of all significantly speed up the process of conducting material for the performance review, but also allow for more detailed and in-depth performance reviews as a larger amount of data could be used in the evaluation. This enables Volvo Cars to more easily identify if the train operators' are not performing as per agreement as well as help them specifically point out which areas of the train operators' operations are lacking and where they need to improve. All the mentioned aspects contributes towards the advancement of the overall train process, which aligns with Rutner and Gibson (2002) who express that using a TMS allows for gathering of historical data that can be used to continuously improve and evaluate processes.

5.2 Analysis related to RQ2 and RQ3: Information attributes and potential effects

This second section of the chapter aims to analyze the empirical finding in relation to RQ2 and RQ3. Since the majority of RQ2 has been answered in Section 4.2, this section will instead focus on discussing the results regarding the classification of information attributes as "Must haves" and "Nice to haves". In addition, some aspects of RQ3 will also be reflected upon.

5.3 "Must have" information attributes

The findings clearly show that there are multiple information attributes existing in the system today. However, some are more important than others for the rail freight network and therefore, the most critical information attributes were classified as "Must haves". Some of these attributes were classified as "Must haves" due to the technical requirements of the TMS whilst other were classified as "Must haves" because they have a great impact on the rail freight network. Firstly, *Train ID*, *Wagon ID* and *Container ID* were classified as must haves since the system requires

this structure to enable complete visibility of the train during transportation. The importance of visibility is discussed by Somapa et al. (2018) and how it can be used to enhance both strategic and operational activities. Without these information attributes the other information attributes would not be relevant since the information provided could not be connected to a specific train, wagon or container. Furthermore, *Bill of lading* was deemed as a "Must have" since this is a legal requirement of any rail freight transportation (Beecher, 2006). Having access to this document through a single system also improves information sharing capabilities and accessibility (Buijs and Wortmann, 2014).

The remaining information attributes deemed as "Must have" are *Tactical Window*, *Actual time of delivery*, *Actual time of departure*, *Deviation reporting*, *ETA*, *ETD*, and *Train status*. Firstly, *Tactical window* refers to the time window when the train is scheduled to arrive and departure from a given location. This information is critical for allocating resources necessary for handling the train once it is in place. Zhao and Goodchild (2013) state how using tactical window information reduces the inaccuracy of this type of information and thereby improves its quality. Additionally, in combination with *Actual time of delivery* and *Actual time of departure*, *Tactical window* information enables Volvo Cars to analyze how well Train operator A and Train operator B performs regarding their delivery accuracy. Without the *Tactical Window*, tracing historical data on the deviations would not be possible and therefore limit the organizations capability to continuously improve their train operations.

In addition to this, *ETA* and *ETD* provides operational information regarding when the train is supposed to arrive or departure from a specific location and in cases the time deviates from the *Tactical window*. In combination with the *Deviation information*, *ETA* and *ETD* provides the information needed for the operational workers in the train process to be flexible and adjust the process according to the situation at hand. Furthermore, by having detailed and accessible *Deviation information* the organization can analyze the transportation flow in a more efficient manner. This argument aligns with Kalaiarasan et al. (2022) who state that improved visibility through increased information access enhances the predictive capabilities and deviation management of a company. Understanding what issues are occurring often and where in the process they occur is beneficial in the optimization and improvement of the overall transportation flow.

Lastly, *Train status* provides much closer possibility for actors to monitor the process and identifying trends that otherwise would be difficult to detect. Increasing the number of check-points along the routes, where the status is updated at each check-point, will provide more data to analyze. This could once again be used to optimize the transportation flow as well as connect and isolate certain information to specific geographical locations. Using this specified information, bottlenecks along the transportation routes could be identified, which provides improvement opportunities.

5.4 "Nice to have" information attributes

The classification of "nice to have" information attributes refers to those that are not critical for the train operations to function properly, but can still generate value in terms of efficiency for the organization. As Jacobsson et al. (2017) states, it is important to understand what information attributes are important and how they contribute. Therefore, it was important to rank the information attributes in order to focus the implementation towards the information attributes that contributes value whilst not being too costly to implement. The ranking was done using the theoretical model BWM described in section 4.2.4.3 as well as the survey. The result of the BWM clearly puts *Train fill rate* as the most attractive information attribute to include in the TMS. However, it only received four out of seven votes from the survey where two of them put it at the top priority. This shows that the results from the BWM put it as a much higher priority compared to the respondents of the survey. This difference can likely be explained with the slightly less complex structure of the survey, where the respondents got the opportunity to describe what information attributes are important to them without any consideration of the cost of implementation and maintenance.

According to the survey two of the most important information attributes are the *Train status 2.0* and *Position* whilst in the BWM ranking they ended up in the bottom of the list. One could argue that this difference occurred due to both *Train status 2.0* and *Position* having a substantial effect on the rail freight network but they also include a large implementation threshold due to the nature of the information attributes, being difficult to implement, which was most likely not considered by the respondents of the survey. Moreover, since *Train status 2.0* and *Position* include information from several actors and requires communication between several systems, it is very complex to include in an initial implementation stage (Perego et al., 2011), which makes it appropriate to implement at a later stage.

Another interesting finding when comparing the BWM and the survey is the ranking of *Emissions*. In the early stages of this thesis, tracking *Emission* was a selling point as it was mentioned in multiple interviews. However, in the survey, *Emission* did not receive a single vote. This result was interesting and might be explained by the reason that the responsibility of sustainability is divided from the operational operations of the rail freight network. As Ones and Dilchert (2012) states, educating and sharing the importance of sustainability throughout the organization is paramount for increasing the environmental performance of the organization. In order to increase the priority of tracing *Emission* in the rail freight network, the value of sustainability must be communicated downwards in the organization to those working with the system and reporting the information.

Furthermore, when the implementation of the TMS is in place and the operations are running, the situation might change the ranking of the "Nice to have" information attributes with the experience from using the TMS. The findings in this thesis

is based on information provided by Volvo Cars with the perspective of the current state of the rail freight network which is subjective and might not be accurate. However, the "Nice to have" information attributes will function as a guideline for Volvo Cars towards understanding how to approach implementing new information attributes and what to prioritize.

5.5 Recommendations for Volvo Cars

The findings of this thesis provide valuable information on how to proceed with the implementation of the TMS. This section serves as a guideline for Volvo Cars on how to successfully implement the TMS. This includes responsibilities for actors involved, the importance of automation and what information attributes to include.

Inbound logistics at Volvo Cars (located in Plant A) started the initiative of implementing a TMS for the rail freight network. Therefore, they have a responsibility to drive the implementation forward and assign responsibilities for each activity of the process. Along with this they are responsible for clearly communicating why this change is needed and how it will benefit the organization and the actors involved. As discussed, there is organizational inertia that needs to be addressed once introducing change, and a key to solving this issue is to make everyone involved in the change aware of why it is necessary and how it will affect them as individuals and the organization as a whole.

In order for the implementation to work efficiently and provide the wanted benefits, Volvo Cars should aim to use their technological capabilities to automate as much of the process as possible. Avoid introducing tedious manual labor and reduce the risk of misunderstanding through manual information exchange. However, in the early stages of the implementation, some activities might be worth monitoring or handling manually to identify any errors or malfunctions in the process.

Regarding what information attributes to include, the attributes classified as "Must haves" should be implemented, tested and fully functional before Volvo Cars commit to solely rely on the TMS for monitoring the rail freight network. Once this has been achieved, the "Nice to have" information attributes should be introduced as soon as possible since they will contribute value to the process, increasing the overall advantage of using a TMS. The finding of this thesis can be used as a guidance on what "Nice to have" information attribute to prioritize. However, as stated in section 5.4 the needs might change once the system is in use and therefore these information attributes might change priority.

5.6 Future research

A limitation of this study is that the results are based on a case study of Volvo Cars. Their specific rail freight network has been the center point of the research which creates the need for future research of other organizations with rail freight networks. Conducting a comparative study of multiple organizations and comparing

similarities and differences would complement the research provided in this thesis.

This study has also been limited to the TMS that Volvo Cars uses today. Therefore, investigating other opportunities could contribute to the research by providing information that has been overlooked in this study. Furthermore, a study on what TMS system is most appropriate for rail freight could further benefit organizations in the market of changing to or implementing a new TMS.

Due to the geographical limitation, this study has not revealed differences of TMS implementation for organizations in different geographical locations. To complement this study, research of prerequisites for other geographical locations could provide insight in differences regarding regulatory and standard compliance that the TMS need to achieve.

Since this thesis is limited to investigating the organizational prerequisites of a TMS implementation, further research of how the implementation process should be conducted would provide additional value for Volvo Cars and organizations in similar situations. This future study could dive deeper into the implementation process, include more technical details or investigate the end result of the implementation after the TMS has been fully implemented.

6 Conclusion

This thesis was conducted with Volvo Cars to investigate the organizational prerequisites of a Transport Management System (TMS) implementation. The study has focused on three research questions which involves mapping Volvo Cars' rail freight network, finding the critical information attributes for a successful implementation as well as identifying the potential effects of the implementation.

The result of this thesis shows the complexity of Volvo Cars' rail freight network due to the numerous actors involved and the specific characteristics of rail freight transportation. This complexity highlights the need for an effective TMS implementation to improve the efficiency and optimization of the network overall.

The findings and analysis of the communication channels and existing information attributes of the network reveals what information attributes are necessary for a successful TMS implementation as well as the benefits of centralizing information exchange into a single overarching system.

Furthermore, potential effects of the TMS implementation has been presented, focusing on the operational and strategic effects. The findings of this thesis clearly shows that there are multiple benefits from implementing a TMS such as, lowering the risk of miscommunication, increasing data generation for optimization and increasing the pace of decision-making. However, there are also some barriers to overcome when introducing a TMS including technical, human and economic limitations that have been addressed in this thesis.

A recommendation has also been provided to Volvo Cars regarding how to proceed with the TMS implementation. This recommendation includes what information attributes to prioritize, a description of actor responsibility regarding the implementation as well as the importance of automating as much as possible.

In conclusion, this thesis contributes towards the research regarding TMS implementation of rail freight, identifying the organizational prerequisites of TMS implementation for a private organization with a rail freight network. Furthermore, this thesis can serve as a guide for organizations looking to implement a TMS system to increase efficiency and optimize their own rail freight networks.

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Appendices

A Interview guide

General

- Is it O.K. to record this interview?
- Can you give us a short presentation of yourself? Who are you and what is your role?

RQ1: Mapping of Actors, Activities and Resources

- What is your role in the train transport process?
- What activities do you conduct? (e.g. transport, communication, goods receipt, deviation reporting)
- Which resources are used to conduct the activities you described? (e.g. train, personnel, IT-system etc.)
- Which actors are you communicating with today?
- What type of information do you share/receive today? And from whom?

RQ2: Identifying information attributes

- What information attributes are important for you to communicate?
- Is there any information that you lack today?
- Which resources are used to conduct the activities you described? (e.g. train, personnel, IT-system etc.)
- What issues could/does arise during transports today?
- Is there anything with the current system that you feel could be done better?

RQ3: Potential effects of a TMS implementation

- How do you think an implementation of a TMS would affect your daily work activities?
- What would be the positive effects of this implementation?
- What would be the negative effects of this implementation?

Closure

- Is there something you would like to add?

B Existing information attributes

Table 8: *Detailed table of the identified existing information attributes*

Actor	Information attributes	Description	Reference
Logistics Operations (Plant A)	Train ID	Identification number of the train	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Wagon ID	Identification number of the train wagon	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Container ID	Identification number of the container	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	ETA	Estimated Time of Arrival (ETA) measures when the train is expected to arrive to its destination	(Dürr & Giannopoulos, 2003; Lowe, 2005; Wang & Hu, 2016); Interviews
	Deviation information	Information regarding changes in schedule that affect the original ETA	(Sternberg, 2008); Interviews; Internal documents
	Goods priority information	Information that indicates the urgency of a certain component e.g. due to shortage. Given priority can speed up the transport	(Sternberg, 2008; Trafikanalys 2014); Interviews
	Time of delivery	Planned time window for the delivery to occur	(Andersson et al., 2005; Stefansson & Russel, 2008); Interviews
	Alternative route	Information regarding the new route taken when the original route cannot be used due to e.g. construction work or other barriers along the track	(Andersson et al., 2005; Sternberg, 2008; Wang & Hu, 2016); Interviews
	Invoicing	Information about payments connected to the transportations of the trains	Interviews
Optimization (Plant A)	Train ID	Identification number of the train	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Container ID	Identification number of the container	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Time of delivery	Planned time window for the delivery to occur	(Andersson et al., 2005; Stefansson & Russel, 2008); Interviews
	Invoicing	Information about payments connected to the transportations of the trains	Interviews
Terminal Operations (Plant A)	Train ID	Identification number of the train	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Wagon ID	Identification number of the train wagon	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Container ID	Identification number of the container	(Sternberg, 2008; Wang & Hu, 2016); Interviews

B Existing information attributes

	ETA	Estimated Time of Arrival (ETA) measures when the train is expected to arrive to its destination	(Dürr & Giannopoulos, 2003; Lowe, 2005; Wang & Hu, 2016); Interviews
	Deviation information	Information regarding changes in schedule that affect the original ETA	(Sternberg, 2008); Interviews; Internal documents
	Estimated pick-up time	When the goods are expected to be picked up at the terminal	(Sternberg, 2008)
	Goods priority information	Information that indicates the urgency of a certain component e.g. due to shortage. Given priority can speed up the transport	(Sternberg, 2008; Trafikanalys 2014); Interviews
	Time of delivery	Planned time window for the delivery to occur	(Andersson et al., 2005; Stefansson & Russel, 2008); Interviews
	Capacity of the terminal	Status regarding the capacity of the terminal. E.g. if the terminal is overloaded due to production stop	(Trafikanalys, 2014; Wang & Hu, 2016); Interviews
Plant B	Container ID	Identification number of the container	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Deviation information	Information regarding changes in schedule that affect the original ETA	(Sternberg, 2008); Interviews; Internal documents
	Goods priority information	Information that indicates the urgency of a certain component e.g. due to shortage. Given priority can speed up the transport	(Sternberg, 2008; Trafikanalys 2014); Interviews
Transport Coordination (Plant C)	Train ID	Identification number of the train	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Wagon ID	Identification number of the train wagon	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Container ID	Identification number of the container	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	ETA	Estimated Time of Arrival (ETA) measures when the train is expected to arrive to its destination	(Dürr & Giannopoulos, 2003; Lowe, 2005; Wang & Hu, 2016); Interviews
	Deviation information	Information regarding changes in schedule that affect the original ETA	(Sternberg, 2008); Interviews; Internal documents
	Goods priority information	Information that indicates the urgency of a certain component e.g. due to shortage. Given priority can speed up the transport	(Sternberg, 2008; Trafikanalys 2014); Interviews
	Alternative route	Information regarding the new route taken when the original route cannot be used due to e.g. construction work or other barriers along the track	(Andersson et al., 2005; Sternberg, 2008; Wang & Hu, 2016); Interviews
Terminal Operations (Plant C)	Train ID	Identification number of the train	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Wagon ID	Identification number of the train wagon	(Sternberg, 2008; Wang & Hu, 2016); Interviews

B Existing information attributes

	Container ID	Identification number of the container	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	ETA	Estimated Time of Arrival (ETA) measures when the train is expected to arrive to its destination	(Dürr & Giannopoulos, 2003; Lowe, 2005; Wang & Hu, 2016); Interviews
	Deviation information	Information regarding changes in schedule that affect the original ETA	(Sternberg, 2008); Interviews; Internal documents
	Estimated pick-up time	When the goods are expected to be picked up at the terminal	(Sternberg, 2008)
	Goods priority information	Information that indicates the urgency of a certain component e.g. due to shortage. Given priority can speed up the transport	(Sternberg, 2008; Trafikanalys 2014); Interviews
	Time of delivery	Planned time window for the delivery to occur	(Andersson et al., 2005; Stefansson & Russel, 2008); Interviews
Train Operator A	Train status	Updates regarding the trains status during transportation	Interviews
	Train ID	Identification number of the train	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Wagon ID	Identification number of the train wagon	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Container ID	Identification number of the container	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	ETA	Estimated Time of Arrival (ETA) measures when the train is expected to arrive to its destination	(Dürr & Giannopoulos, 2003; Lowe, 2005; Wang & Hu, 2016); Interviews
	Deviation information	Information regarding changes in schedule that affect the original ETA	(Sternberg, 2008); Interviews; Internal documents
	Estimated pick-up time	When the goods are expected to be picked up at the terminal	(Sternberg, 2008)
	Position	Real time GPS position of the train	(Dynafleet, 2015; Stefansson & Russel, 2008); Interviews
	Bill of lading	Information about the cargo such as weight, part number and destination	(Lumsden, 2006; Stefansson & Russel, 2008)
	Driving times for the driver	Status about how much driving time the driver has left before he/she needs to take a break	(Dynafleet, 2015)
	Breaking status	Information about how much time is left of a driver's break	(Dynafleet, 2015)
	Queuing status	Information about queues when a train enters a hub to e.g. change driver and locomotive	(Jacobsson, 2020)
	Alternative route	Information regarding the new route taken when the original route cannot be used due to e.g. construction work or other barriers along the track	(Andersson et al., 2005; Sternberg, 2008; Wang & Hu, 2016); Interviews

B Existing information attributes

	Invoicing	Information about payments connected to the transportations of the trains	Interviews
Train Operator B	Train status	Updates regarding the trains status during transportation	Interviews
	Train ID	Identification number of the train	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Wagon ID	Identification number of the train wagon	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Container ID	Identification number of the container	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	ETA	Estimated Time of Arrival (ETA) measures when the train is expected to arrive to its destination	(Dürr & Giannopoulos, 2003; Lowe, 2005; Wang & Hu, 2016); Interviews
	Deviation information	Information regarding changes in schedule that affect the original ETA	(Sternberg, 2008); Interviews; Internal documents
	Estimated pick-up time	When the goods are expected to be picked up at the terminal	(Sternberg, 2008)
	Position	Real time GPS position of the train	(Dynafleet, 2015; Stefansson & Russel, 2008); Interviews
	Bill of lading	Information about the cargo such as weight, part number and destination	(Lumsden, 2006; Stefansson & Russel, 2008)
	Driving times for the driver	Status about how much driving time the driver has left before he/she needs to take a break	(Dynafleet, 2015)
	Breaking status	Information about how much time is left of a driver's break	(Dynafleet, 2015)
	Queuing status	Information about queues when a train enters a hub to e.g. change driver and locomotive	(Jacobsson, 2020)
	Alternative route	Information regarding the new route taken when the original route cannot be used due to e.g. construction work or other barriers along the track	(Andersson et al., 2005; Sternberg, 2008; Wang & Hu, 2016); Interviews
	Invoicing	Information about payments connected to the transportations of the trains	Interviews
3PL	Train ID	Identification number of the train	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Wagon ID	Identification number of the train wagon	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	Container ID	Identification number of the container	(Sternberg, 2008; Wang & Hu, 2016); Interviews
	ETA	Estimated Time of Arrival (ETA) measures when the train is expected to arrive to its destination	(Dürr & Giannopoulos, 2003; Lowe, 2005; Wang & Hu, 2016); Interviews

B Existing information attributes

	Deviation information	Information regarding changes in schedule that affect the original ETA	(Sternberg, 2008); Interviews; Internal documents
	Estimated pick-up time	When the goods are expected to be picked up at the terminal	(Sternberg, 2008)
	Bill of lading	Information about the cargo such as weight, part number and destination	(Lumsden, 2006; Stefansson & Russel, 2008)
	Time of delivery	Planned time window for the delivery to occur	(Andersson et al., 2005; Stefansson & Russel, 2008); Interviews

C Desired information attributes

Table 9: *Detailed table of the identified desired information attributes*

Actor	Information attributes	Description	Reference
Logistics operations (Plant A)	Train status	Updates regarding the trains status during transportation	Interviews
	Sequence direction of train wagons	Information regarding which direction the train wagons are connected to the locomotive	Interviews
	Actual time of delivery	Actual time window when the delivery occurs	(Andersson et al., 2005); Interviews
Optimization (Plant A)	Train status	Updates regarding the trains status during transportation	Interviews
	Bill of lading	Information about the cargo such as weight, part number and destination	(Lumsden, 2006; Stefansson & Russel, 2008)
	Container fill rate	How much of the container is filled up with goods	Interviews
	Emission	Emissions created by the train, e.g. Co2	(Trafikanalys, 2014); Interviews
Terminal operations (Plant A)	Train status	Updates regarding the trains status during transportation	Interviews
Plant B	Position	Real time GPS position of the train	(Dyna fleet, 2015; Stefansson & Russel, 2008); Interviews
Transport Coordination (Plant C)	Train status	Updates regarding the trains status during transportation	Interviews
	Position	Real time GPS position of the train	(Dyna fleet, 2015; Stefansson & Russel, 2008); Interviews
Terminal operations (Plant C)	Train status	Updates regarding the trains status during transportation	Interviews
Plant B	Position	Real time GPS position of the train	(Dyna fleet, 2015; Stefansson & Russel, 2008); Interviews
3PL	Train status	Updates regarding the trains status during transportation	Interviews
	Goods priority information	Information that indicates the urgency of a certain component e.g. due to shortage. Given priority can speed up the transportation	(Sternberg, 2008; Trafikanalys 2014); Interviews
	Alternative route	Information regarding the new route taken when the original route cannot be used due to e.g. construction work or other barriers along the track	(Andersson et al., 2005; Sternberg, 2008; Wang & Hu, 2016); Interviews

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