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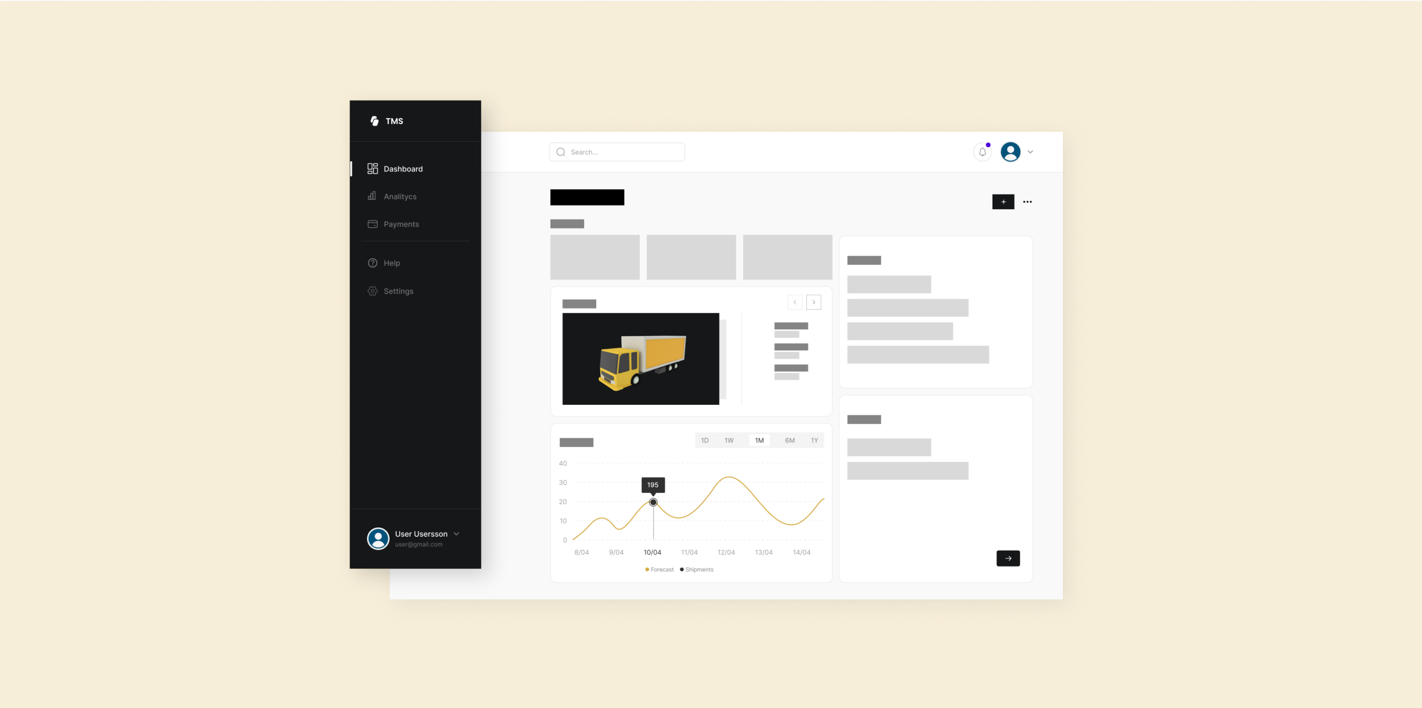

Diffusion of Technology within the Carrier Industry

A QFD approach to examine TMS offerings for carriers

Master's thesis in Supply Chain Management

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Cover: Sketch of a user interface of a TMS visualizing the starting page when logged in.

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Abstract

The transportation industry, where the entire procedure of moving goods is encompassed, is a vital component of the business world that affects multiple sectors. The primary system used by carriers that execute the assignment is a TMS, which assists in the process of managing shipper transportation needs for order delivery. Conversely, carriers have elevated expenses and delays due to the lack of focus on innovative IT solutions. By recognizing the customer's requirements for services, benefits in both effectiveness and efficiency can arise for carriers. Therefore, it is important to identify these requirements and also examine how TMS providers can effectively address the needs of carriers.

This thesis aims to investigate the interaction between carrier requirements and TMS providers in order to understand how TMS providers can address the needs of carriers. The scope of the thesis is medium to large-sized carriers in Scandinavia. Further, this is a field study in collaboration with a TMS provider, hereinafter referred to as the case company. A QFD approach was made to facilitate the translation of customer requirements into actionable steps for implementation within an organization. Here, both qualitative and quantitative data were collected and analyzed throughout the 6 steps according to the HoQ matrix.

Based on the steps taken, 16 customer requirements were elicited through a thematic analysis of data from semi-structured interviews and an online questionnaire. The requirements were prioritized by the customers using an online questionnaire. Moreover, 14 technical descriptors were discovered through the use of thematic analysis of data from semi-structured interviews with the case company. Subsequently, the strength of the relationship between requirements and technical descriptors was analyzed by an appointed QFD team. Lastly, the correlation between technical descriptors and their development target was determined by interviews with the case company. In conclusion, it was evident that Invoice Management, Order Management, and Data and Analytics Management holds more influence on the selection and adoption of a TMS than other requirements. Dispatch System was the technical descriptor that address the most requirements. Nevertheless, the remainder of customer requirements and technical descriptors should not be disregarded.

Keywords: qfd, carrier, tms, tms provider, road freight, transport, carrier technology, hoq, service quality, carrier requirements.

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Second, we would like to express our gratitude to the case company for the opportunity to conduct this study in collaboration with them. To all individuals at the case company who have supported us throughout this journey and made substantial contributions that have led to the successful attainment of our desired outcome, we express our deepest appreciation.

Third, we would like to show our appreciation to the opposition team for their valuable contributions during the defense of this thesis. Their insightful questions, constructive criticisms, and thought-provoking discussions have greatly enriched our research and helped us refine our work.

Finally, we would like to thank our supervisor and examiner Ceren Altuntas Vural, Associate Professor at the Divison of Service Management and Logistics at Chalmers University of Technology. She has provided us with support, insights, and unwavering commitment to assisting us throughout the process of writing this thesis.

Robin Egert, Robin Repo Wecklauf, Gothenburg, June 2023

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

HoQ	House of Quality
TMS	Transport Management System
QFD	Quality Function Deployment

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1
Introduction

This chapter will describe the background, to contextualize the thesis and to provide the aim. Additionally, the research questions that will be answered throughout the thesis will be stated, followed by the limitations.

1.1 Background

The transportation industry plays a vital role in the business world as it ensures the availability of goods on shelves, timely delivery of purchased items to e-commerce customers, and supplies factories with necessary raw materials for processing [3]. Therefore, it is a crucial industry that affects and supports numerous other industries. Europe's road transport industry accounted for a significant 24.6% of total freight transportation in 2021 [4]. This translates to a market size of USD 250 billion in 2019 [5], highlighting the scale and importance of this sector.

Despite the importance of this sector, the road freight industry is outdated and ripe for digital innovation [6]. Low profit margins and reliance on manual procedures have left traditional players without an incentive to invest in new technologies. However, digital startups are introducing new business models and addressing inefficiencies, particularly in the Western European market. Outdated customer interfaces result in delays and additional costs, but digital startups are targeting these pain points with technologies like real-time cargo tracking and AI optimization. This transformation presents an opportunity for customers to benefit from improved service and lower costs, and established players will need to adapt to remain competitive [6]. Road freight transportation involves using motor vehicles to transport goods from their origin to their intended destination [7]. The logistics system involved in this process includes various actors operating at different levels, such as shippers, forwarders, carriers, and drivers [2]. The extent of the carrier's involvement depends on the logistics arrangement established by the forwarder, who typically assumes the role of transport coordinator.

The transport coordinator usually uses a TMS, which streamlines and integrates all transportation-related activities and participants in the logistics process using digital technology [6]. Further, it is designed to meet the needs of effective carrier communication and coordination within an enterprise's transportation operations, ensuring a streamlined and efficient process [8]. In order for the TMS to meet their specific needs, there must be a focus on service quality, which refers to the degree to which a service meets the expectations of its customers [9]. However, enhancing service quality poses numerous challenges for companies, such as poor visibility, accountability, and the unpredictable nature of service delivery. QFD is a method used to ensure that new products are designed with quality in mind [10], and it can also serve as a helpful framework for managing software requirements [11]. The first phase in QFD is called Product Planning, and is referred to as the HoQ [12]. As this phase is often used in non-manufacturing settings, adaptations were made to the traditional HoQ to make it more suitable for software development.

Due to the character of the carrier industry, software development research in the field has not been extensive. Additionally, there is not much research literature using a QFD approach for software development. Road freight carriers are not known for using technology. With the ongoing advancement of software technology, carriers stand to gain significant benefits by incorporating and deploying technological advancements throughout their operations. By using a QFD approach, this thesis aims to discover what TMS providers should focus on by making useful and practical software functions that attract carriers.

1.2 Aim

This master thesis aims to examine the interaction between carrier requirements and TMS providers in order to understand how TMS providers can effectively address the needs of carriers. Additionally, the thesis aims to identify the carrier requirements that hold the potential to impact the selection and adoption of a TMS. To concretize what the thesis intends to accomplish, the aim has been divided into the following research questions:

- What are the carrier requirements that have the potential to influence their selection and adoption of a TMS?
- How can the carrier requirements be addressed by TMS providers?

1.3 Limitations

In this thesis, all carriers with less than 20 trucks or more than 100 trucks will not be taken into consideration. The span between 20 trucks and 100 trucks is defined, in this thesis, as medium to large-sized carriers, and will be of relevance. Furthermore, the thesis focused solely on domestic transportation. Another limitation of this study is that it concentrated on semi-trailer trucks and EuroCombi trucks, neglecting the examination of other vehicle types or modes of transportation. The geographical scope will be limited to Scandinavia.

Another limitation regards the intended user of the technology at the transport carrier. There are many areas where technology can be of use for a carrier; this project will only target one user: a transport dispatcher. Based on the dispatcher's general tasks, the proposed technology will include and be limited to the following functions: management of shipments, resources, and planning.

In this thesis, autonomous technology will not be taken into account. Autonomous processes and/or functionalities might be of relevance in a software-related context, but not in this report.

2
Literature Review

This chapter will present and describe the literature review that will shape the study's research, which includes literature on the transport sector, carrier industry, TMS, and service development. First, a general overview of the transport sector will be provided, followed by an in-depth exploration of the carrier industry. Second, the importance of TMS will be described, followed by an overview of a road freight transport system. Lastly, the concepts of product-service system, software-as-a-service, and service quality will be examined and connected to road freight transportation.

2.1 Road Freight Transport

This section will categorize road freight transport into three subsections: the transport sector, carrier industry, and transport management system. The first two subsections will be described first, followed by TMS, and finally, these components will be contextualized within the broader road transport system.

2.1.1 Transport Sector

The segmentation of the Europe Road Freight Transport Market includes end-user, destination, truckload specification, containerization, distance, product type, temperature control, and the country [13]. Within the EU, of which Scandinavia is a part of, national transport (65%) constitutes the majority of road freight transport as compared to international transport (35%) [14]. In 2021, 24,6% of freight was transported on roads in Europe [4], which in 2019 amounted to a market size of USD 250 billion [15]. Currently, road freight is responsible for 53% of CO_2 emissions in transport related to global trade [16]. Further, if present patterns persist, this percentage is projected to increase to 56% by 2050.

In Sweden, the transport sector is large and varied. Approximately 30,000 companies in the sector employ nearly 240,000 people and have an annual turnover of around 500 billion SEK [3]. It is also an important industry for the rest of the business world, since the transportation industry makes sure that there are goods on the shelves, that e-commerce customers get their purchased goods, and that factories have raw materials to process [3].

In 2019, the total volume of goods transported in Europe amounted to 1764 billion tonne-kilometres [5]. In Sweden, it amounted to 103 billion tonne-kilometres, divided between road, rail, sea, and air [3]. More than half of all transport work in Sweden is carried out by road [3]. This means that truck transport forms a significant part of Sweden's supply of goods and freight. The transport industry plays an important role in the Swedish economy. The share of industry in total economic turnover was around 5.4% in 2018 [3]. This means that a little over one-twentieth of the economic turnover can be attributed to various sectors of the transport industry. If you instead focus on value creation, the industry's contribution to gross domestic product (GDP), the share was about 5.8% in 2018 [3].

Nearly 15,000 Swedish companies, mainly trucking companies, ensure trucking in Sweden [3]. Together, these companies employ more than 64,000 full-time workers - more than 1% of Sweden's workforce, or as many as live in a medium-sized Swedish city. Every year, 450 million tons of goods are transported by truck on Swedish roads. However, if you also consider the total distance (in tonne-kilometers) over which goods are transported, the various general cargo and LCL cargoes make up the largest categories. Most of Europe's cargo is moved by truck, and long-haul competition is fierce, including from German and Polish freight forwarders [3]. However, the vast majority of broadcasts are local or regional and over relatively short distances. About half of the hauls were shorter than 25 km. This is partly because trucks are a flexible mode of transport that can move goods to and from relatively remote locations before offloading them to other modes of transport that require more extensive infrastructure, such as trains, ships, or planes [3].

2.1.2 Carrier Industry

The road freight sector in Western Europe comprises over 300,000 carriers with varying sizes, ranging from small owner-driver operations to multibillion-euro companies where DB Schenker, the largest player, holds only a 2.1% market share [6]. Due to such market fragmentation, competitors often collaborate to achieve economies of scale and provide customers with better value propositions. However, the lack of trust within the industry has hindered this collaboration and prevented companies from reaping the associated benefits. The primary basis of competition in this industry is price, influenced by the supply and demand for freight capacity. Customers have limited information on rates, capacity, and the reliability of carriers [6]. The industry's elevated expenses have been further compounded by the insufficient implementation of automation and digitization in critical operations such as dispatching, order management, and load consolidation [6]. Additionally, traditional paper-based processes have frequently led to the loss of vital information. Although web-based customer interfaces have facilitated effortless, streamlined, and prompt transactions for various industries, the same cannot be said for road freight. Outdated interfaces are prevalent in this sector, mainly caused by the use of outdated IT systems. Customers often have to endure extended processes to receive a quote, intricate documentation procedures, and a shortage of real-time cargo tracking [6].

Ensuring efficient management of resources is crucial for achieving profitability [17]. To optimize resource utilization in transportation, it is insufficient to concentrate solely on the movement of goods [18]. While goods flow from sender to receiver in a one-way direction, resource flow operates in both directions. This includes the return of resources (such as trailers, containers, or pallets) from their destination to their point of origin, whether filled or empty. Any disparities in the flow of goods can result in losses in resource utilization [18]. In the transport industry, vehicles represent a crucial resource that can be easily replicated by competitors [19]. However, combining this tangible resource with other tangible and intangible resources like terminals, networks, knowledge, and skills can create a competitive advantage for a company. Further, effective management of vehicles and their utilization can put a company in a better position than its competitors. Improving the fill rate is one way of achieving this capability [19]. Given that the transport sector contributes significantly to emissions, and road freight transport is the primary mode of freight transportation in most countries, efficient use of vehicles could significantly reduce this burden.

The emergence of technological progress has highlighted the need to minimize repetitive procedures and lower inventory levels throughout the supply chain [20]. Consequently, these challenges have underscored the criticality of achieving dependable, superior, and uniform transportation outcomes to fulfill the objectives of the supply chain. The overall expenses associated with logistics have been rising annually, with transportation costs, particularly those related to trucking, representing a significant portion of the increase [20]. Moreover, the quantity of freight being transported continues to expand, leading to aggravated traffic congestion, persistent driver shortages, and unpredictable fuel prices. The growing significance of transport sustainability, driven by tightening policy requirements, has made the adoption of green transportation solutions more than just a trend. Sennder, a forwarder, witnessed a fivefold increase in its volumes of green loads (including renewable diesel, electric, and multimodal transports) shipped through their platform in 2022 [21]. Additionally, the trend is anticipated to persist into 2023.

The relationship between shippers and carriers is highly imbalanced historically, with shippers enjoying a position of significant power [20]. Following the deregulation of the trucking sector [in the US], for instance, several attendees revealed that shippers developed adversarial associations with carriers and could manipulate them to accept meager profit margins by negotiating aggressively on price. This led to a relationship between shippers and carriers characterized by competitive interactions, which were somewhat strained. The power dynamic in shipper/carrier relationships has undergone a shift due to industry constraints that have stretched carrier capacity [20]. The demand has exceeded supply in several markets, which has led to a reduction in opportunistic behavior by shippers and competitive bargaining in shipper/carrier relationships. Furthermore, carriers now have the ability to resist unreasonable demands made by shippers, thereby increasing their independence and reducing their dependence on shippers. As a result, both the symmetry and magnitude of the relationship have increased. Carriers can selectively choose only the most lucrative customers, with some even firing unprofitable customers [20]. The need for reduced inventory and shorter cycle times to boost supply chain efficiency, coupled with capacity constraints, has prompted shippers to pay closer attention to their relationships with carriers, leading to more cooperative interactions and stronger organizational ties [20].

The organization of present-day road freight transportation markets is characterized by automation, with the majority of carriers running small fleets [22]. In general, the vehicles utilized by carriers for road freight transportation belong to small fleets, resulting in fragmented planning and control of such transportation. This has a substantial impact on the efficiency and utilization of truck fleets, ranging from corporate transport demand planning at the macro level to individual driver control at the micro level [23][24]. While road freight transportation may seem straightforward at times, such as when a national operator with its own fleet handles end-to-end transport, almost every logistics service provider is also engaged in more intricate arrangements involving various actors [22]. For instance, when assigning shipment orders to subcontracted carriers.

2.1.3 Transport Management System

A TMS facilitates the integration of all transportation-related activities and participants within the logistics process through digital means [6]. Moreover, it is designed to fulfill the requirements of streamlined and effective carrier communication within an enterprise's transportation operations [8]. This assists the process of managing shipper transportation needs for order delivery [25]. Therefore, a TMS needs a set of functionality that can achieve this. Verwijmeren mentioned, in 2004, the following basic functions in a TMS: (1) transport booking; (2) transport planning; and (3) transport monitoring [25].

Transportation services can be classified based on their primary cost drivers, which include transportation quantity, transportation distance, and service level (transportation speed) [8]. A basic TMS, comprised of functions (1), (2), and (3), covers these cost drivers for carriers. However, with rising transportation costs due to fuel costs and driver shortages, solutions are actively searched for to mitigate these challenges by attempting to minimize or eliminate common pain points [26].

Focusing on new solutions, new TMS addresses more features that are advantageous to carriers by reducing costs [6]. More specifically, the features improve logistics operations by increasing efficiency and productivity by generating optimized transportation plans, schedules, and routes, as well as help in selecting drivers with the appropriate skills [27]. Additionally, it assists carriers in choosing profitable loads and identifying the best loads for drivers, considering factors such as hours of service and personal preferences. Moreover, it focuses on customer service and satisfaction by enabling users to assess the impact of decisions on both profit and service quality individually, allowing for the offer of superior customer service. In general, the decisions regarding transportation can have a significant effect on every facet of a business, ranging from customer satisfaction and the accessibility of products to overall profitability [28].

The decisions made by TMS are, therefore, important for a business. The role played by TMS technology can be considered crucial as it assesses the impact of uncertainty and fluctuations within transportation networks, enabling companies, including shippers and carriers, to better manage logistics [28]. Santos and Costa mention that collecting, storing, processing, and analyzing data is becoming progressively demanding and companies that are capable of achieving this and extracting business benefits from it will attain a notable edge over their competitors [29]. Using data, the TMS is progressively automating tasks, thereby replacing manual processes, with the objective of leveraging available resources to work more intelligently while simultaneously decreasing costs and efficiently expanding the business [28].

2.1.4 Road Freight Transport System

Road freight transportation refers to the complete process of transporting goods by road using motor vehicles, from their point of origin to their intended destinations [7]. Road freight transportation systems consist of intricate inter-organizational arrangements that encompass various actors with diverse functions, forming a network of interconnected entities [22]. Transporting goods is associated with a logistics system, which encompasses numerous actors operating at various levels of the system and maintaining diverse types of relationships among those levels [2], as visualized in Figure 2.1. The process encompasses all the necessary activities involved in the transportation of the goods.

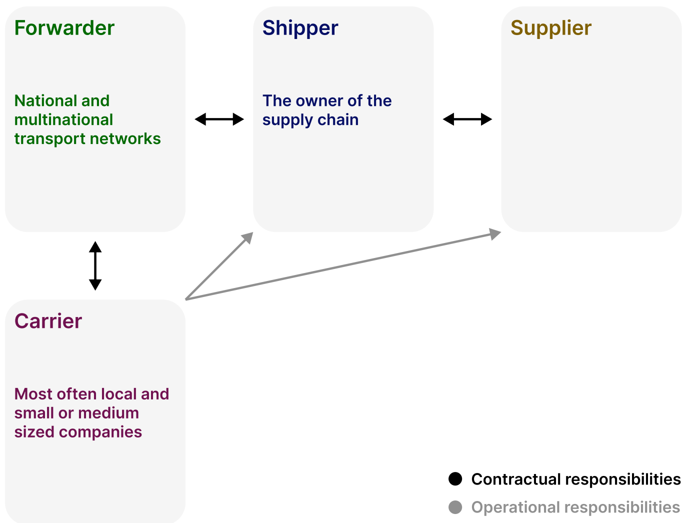


Figure 2.1: Road freight transport system showing the relationships between stakeholders [1][2]

Here, it is visualized that the shipper has contractual responsibilities to both the supplier and forwarder. Shippers are organizations that own the goods and initiate the shipping process [30]. This is derived from a transportation need and therefore compensates a forwarder to perform the specified transport. Connected to the

transport, the forwarder contracts a carrier to execute the assignment; the carrier possesses the vehicles and hires drivers. This is because a forwarder, sometimes referred to as a freight forwarder, functions as a provider of transportation services [30]. During the transportation assignment, the carrier partner may need to liaise with the shipper and, if applicable, its suppliers (depending on the logistics arrangement). This is visualized by the operational responsibilities. The extent of the carrier's involvement will depend on the arrangement established by the forwarder, with the forwarder typically assuming the role of transport coordinator.
New technologies are now indispensable in the road freight transportation system, as they facilitate the integration of various transportation systems by enabling real-time monitoring of traffic, as well as the detection, communication, and transmission of information [31]. Additionally, these technologies can be implemented across various levels of the transportation system, such as freight, infrastructure, and vehicles [32]. Hence, it can be stated that diverse technologies can be employed in freight transportation operations [33], and enable particular functionalities in freight transportation systems [34].

The TMS is a crucial component of the system architecture for a road freight transportation system. This information system can either be a standardized software package with parameter configuration or customized software programs that cater to a company's specific requirements [25]. Further, the fundamental systems in a transportation supply chain offer distinct functionalities for typical users. As Figure 2.2 demonstrates, there are several stakeholders involved in making use of a TMS. Usually, a forwarder or a carrier uses a TMS for transport bookings, planning, and monitoring. The software components collectively form a system layer that is exclusively designed for managing the supply chain [25]. Further, the components are called supply chain engines (SCEs) and offer the necessary adaptability and intelligence to effectively manage dynamic supply chains as a cohesive whole. While the TMS primarily concentrates on internal management, the SCEs provide additional features and information for managing the external aspects of the supply chain architecture [25].

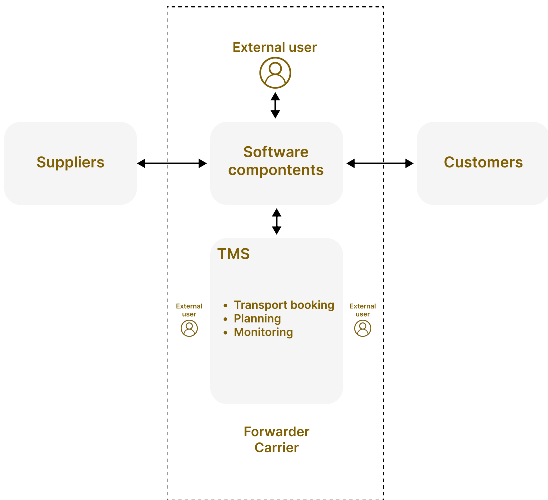


Figure 2.2: Map of TMS stakeholders

2.2 Service Development

In this section, a product-service system will be described and connected to a TMS. Thereafter, service quality and customer satisfaction will be explained. Lastly, service quality and customer satisfaction will be described in a road freight transportation context.

2.2.1 Product-service System

Arnold Tukker defines a product-service system (PSS) as comprising tangible products and intangible services that are intentionally combined to effectively meet the specific needs of customers [35]. Use-oriented services are further explained as a sub-category to PSS where ownership of the product remains with the provider who is also responsible for maintenance, repair, and control. The lessee pays a regular fee to use the product and typically has unlimited and individual access to the leased product. In the context of this report, a TMS can act as the leased product and therefore a service used by carriers. The advancement of information and communication technology has created a platform for companies to create, produce, and offer services that customers may consider superior [36].

Since TMS is a software and a service, it can be associated with software-as-a-service (SaaS). SaaS is a distribution model where the service provider or software vendor hosts and maintains the application system [37]. Therefore, it is similar to use-oriented services. SaaS applications differ from traditional software applications, leading to distinct requirements for operations and management, architecture, security and privacy, compliance, and quality [38]. The service is then delivered to users through a network where customers purchase the necessary application software vendor services based on their actual needs, ordering the content and length of service and paying the vendor accordingly [37]. Berry claims that SaaS providers that offer TMS have prioritized enhancing user experience by incorporating design principles similar to those found in consumer web applications [39]. As a result, users can arguably use the SaaS application on a daily basis with higher customer satisfaction because of its ease of use. Furthermore, Berry mentions that TMS users can post loads electronically to multiple boards and retrieve carrier vendor quotes for review within the TMS. This has greatly streamlined modern shipping departments by enabling businesses to instantly transact with numerous potential carriers. Therefore, TMS provided by SaaS providers empowers shippers to manage their logistics operations with increased efficiency and effectiveness [39].

One of the key advantages of this service model is that the function configuration can be tailored to meet the diverse and complex requirements of software customers on an individual basis. Prioritizing the customer's needs, which encompass specific levels of quality, and not just functionality, is essential [40]. Consequently, software engineers are responsible for identifying quality requirements, even if they are not initially apparent, and discussing their significance and the challenges involved in achieving them. This suggests that the service to be developed, which in this study's case is the TMS, can effectively meet the carriers' requirements when handling requirements appropriately. In order to address these diverse requirements, SaaS vendors must provide an application with all necessary functionalities and offer clients configuration and customization capabilities to tailor the entire application according to their unique needs [41]. Identifying and addressing clients' diverse requirements during SaaS application development can facilitate easy configuration at SaaS runtime, enabling the application to meet each client's specific needs [42]. However, the development of these requirements still needs to maintain high quality. The quality of a software product can be assessed across three distinct dimensions: Economic, represented by managers' viewpoint; social, represented by user's viewpoint; and technical, represented by developer's viewpoint [43]. When considering software quality, it is essential to take all three dimensions into account [40]. The management team is concerned with the product's overall quality, including time and cost considerations. The user's primary interest is in how well the product satisfies their needs. The developer is mainly focused on meeting performance and functional requirements.

2.2.2 Service Quality

Quality refers to the complete set of characteristics of a product or service that determines its ability to meet specified needs [40]. Service quality is defined as to what extent the service fulfills customers' expectations of that service [9][44]. Further, companies face various challenges in their efforts to improve service quality, including issues related to poor visibility, accountability, and the unpredictable nature of service deliveries [9]. The provider's service level encompasses availability/business continuity, performance, usability, and reliability [44]. Meanwhile, the provider's service capabilities consist of ensuring data security and complying with legal regulations. Motivated staff, a clear comprehension of service quality and its influencing factors, effective measurement systems, and a customer-focused approach are crucial elements in ensuring high service quality [45]. Moreover, service quality has a significant impact on customer satisfaction, and it has been confirmed that satisfaction plays a mediating role in the relationship between service quality and customer loyalty [46].

According to Johnston, there is an expectation-perception gap view of service quality that suggests that customers evaluate service quality based on the difference between their expectations and their perceptions of the service they receive [47]. Further, there is debate about the efficacy of this theory where researchers believe that service quality should be measured using performance-based measures. Nevertheless, Johnston states that companies can enhance service quality and boost customer satisfaction by surpassing customer expectations, such as by providing faster delivery times or improving customer service [47]. Flodén, Bärthel & Sorkina also argues that the identification of customer-important attributes is widely recognized as a crucial factor for companies seeking to enhance competitiveness and increase customer satisfaction [48]. By incorporating these attributes into the development phase of new services and products, companies can gain a better understanding of their customer's needs and requirements [49]. Importantly, when engaging customers in the development of new services, it is essential to have a systematic approach to collecting data on service attributes.

2.2.3 Service Quality in Road Freight Transportation

Transportation and service quality are intricately linked, as time is an essential aspect of movement and a fundamental element of transportation operations [50]. Managing transport operations has three objectives: optimizing efficiency (productivity), ensuring effectiveness, and maintaining flexibility [51]. Carriers may define time effectiveness as transport duration, quality effectiveness as customer service provided, and service effectiveness as responsiveness to customer needs [52].

Therefore, most of the services offered by carriers are connected to customers. Conversely, among 13,000 customers in various sectors, survey results indicated that more than 66% of customers switch from their transport service provider due to inadequate service quality [53]. This emphasizes the importance of service quality to ensure customer satisfaction. The punctuality and safety of deliveries are crucial factors in determining the quality of transport services and the competitiveness of carriers [50]. Service quality attributes are commonly evaluated based on the value of time saved in transportation. These attributes are determined by the clients and are considered to be the foundation of forming an offer adjusted to the needs of the market and the development of potential competitive [50]. To enhance the quality of their services, carriers can undertake internal measures like service investments [50]. However, external factors such as transport and economic policies can also have an impact on service quality.

Poor service quality can cause customer irritation and dissatisfaction, resulting in financial and reputational damage to trucking companies [54]. Further, it is also mentioned that the severity of poor service quality ranges from very low to very high. This suggests that carriers need to focus on a specific area to mitigate the most critical errors to improve service quality. Despite the likelihood of detection being lower depending on the severity of the issue, effective management of fleets and customer complaints can be focused on to help improve service quality and enhance customer satisfaction [54].

Customer satisfaction, in a road freight transportation context, is a result of aligning service quality with customer expectation [50]. Therefore, customer satisfaction plays a critical role in determining the level of service quality. Enhancing service quality and customer satisfaction can ultimately result in economic benefits for carriers, which implies it being an important aspect of road freight transportation [54]. This suggests that innovations within road freight transportation must take this into consideration.

The core objective of innovations in freight transport is to achieve a significant improvement in service quality for customers while simultaneously decreasing the costs associated with providing such services [55]. Further, the digitalization of services and the inclusion of service elements into products (i.e., servitization) have primarily driven changes in road freight transport service quality. The digitalization of services is connected to the implementation of information technologies and the introduction of new services, which also influences the service quality and the competitiveness of carriers [50]. Thus, the implementation of a TMS can improve the service quality and enhance the customer satisfaction provided by carriers.

3
Method

This chapter will first present the research design of the thesis. Thereafter, QFD will be described in a section and each step of the HoQ methodology will be explained in respective subsections. First, the step concerning customer requirements is described. Next, the step containing a prioritization of customer requirements is presented. Third, an explanation of the step connected to technical descriptors is provided. Fourth, a relationship matrix between the customer requirements and technical descriptors is described. Lastly, the step that includes the creation of a correlation matrix is provided, followed by a presentation of the development targets for each technical descriptor. At the end of this chapter, the research quality of the thesis is presented.

3.1 Research Design

Stool and Fitzgerald describe a field study as research conducted in a specific, real-world setting to study a specific phenomenon [56]. Further, field studies are unobtrusive and used to develop a deep understanding of a phenomenon in a concrete and realistic setting. Therefore, the authors argue that a field study offers maximum potential for capturing a realistic context. This was done with a case company, which is a freight forwarder that has a TMS. The focus of this thesis was on a generic product, thus not solely on the TMS that is offered by the case company to enhance the generalizability. Based on these definitions and the aim of the study, a field study of Scandinavian carriers will be conducted.

In combination with the nature of a field study and that the purpose of this study fits the methodology, a QFD approach with the HoQ process will be used to answer the research questions in a structured way. The QFD methodology will be described in the following section.

3.2 Quality Function Deployment

QFD is a technique, first applied by Mitsubishi Heavy Industries Ltd in 1972 as a strategy for assuring that quality is built into new products [10]. Further, QFD is systematic and enables the conversion of customer feedback into its means of accomplishment within an organization [57]. The QFD product/service development process or methodology revolves around the creation of a series of matrices [58]. The four phases of traditional QFD consist of Product Planning, Product Design, Process

Planning, and Process Control [12]. The first phase, Product Planning, is referred to as the HoQ [58][12]. Focusing on HoQ, it consists of six steps: Customer needs, Planning matrix, Technical measures, Relationship matrix, Correlation Matrix, and Technical matrix [59]. Karlsson states that QFD is a framework that can be applied to better manage software requirements [11]. Due to the characteristics of this study being a non-manufacturing environment, the traditional HoQ was modified to conform to software development, see differences in Figure 3.1. Further, there are two main differences when transferring QFD to software development; (1) less attention will be spent on the deployment and the ability to prioritize engineering activities will be focused on, and (2) customer requirements can not simply be turned into measurable quality elements to be controlled during development [60].

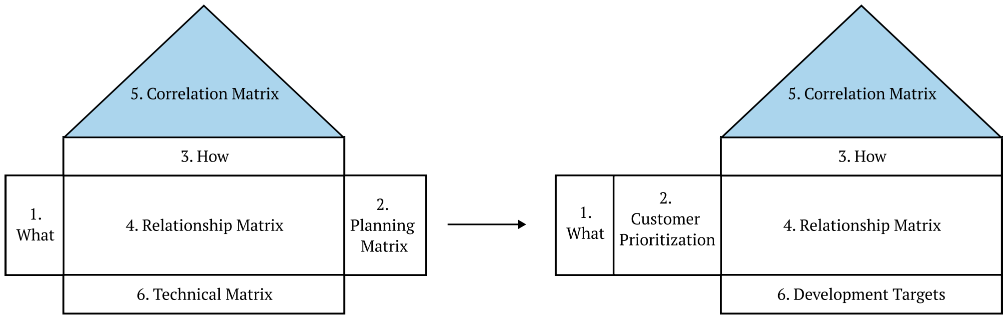


Figure 3.1: Traditional HoQ (left) converted to the study's HoQ (right)

The different steps to build the HoQ that is adapted to software development will be described and presented below in the following subsections.

3.2.1 Step 1: What

This activity represents the left wall of the HoQ and captures the customers' voices regarding needs or expectations in a product [61][11]. Therefore, this study investigated the current systems in use for carrier coordinators and their wants for future systems through interviews and an online questionnaire. Qualitative research is described as a method of translating, understanding, and decoding naturally occurring phenomena in the world [62]. Qualitative data derived from interviews are typically used in a field study [56][62]. The interviews were chosen based on the purposive sampling technique, which involves the deliberate selection of particular units from the entire population to form a sample that represents the universe [63]. The selection was based on the limitations of this thesis, see Section 1.3. Interviews are lauded for their ability to provide insight into the knowledge and experiences of the interviewees, while also facilitating opportunities for them to express individual opinions on specific topics [64]. Interviews can vary in structure, ranging from highly structured to unstructured [65]. Further, structured interviews consist of predetermined, precise questions, while unstructured interviews revolve around a topic without any prearranged questions. This activity was conducted with semi-structured interviews, a flexible tool to explore complicated research questions [66]. There are no standardized question lists that the interviewer must adhere to in unstructured interviews [65]. Instead, questions vary in order depending on the specific interview, allowing for flexibility and openness to new questions that may arise during the discussion. The interview questions were developed based on previous experience and relevant literature, which facilitated a comprehensive understanding of the system carriers use, see Appendix A. This approach also resulted in high-quality data collection from customers during the subsequent phase of the study.

According to Sachdeva, a sample size refer to the specific group of individuals that are deliberately chosen and included in a project [62]. Determining the appropriate sample size for data collection in a study can pose challenges, as there is a constant risk of either exceeding or falling short of the optimal sampling size [63]. Further, a sample size that is too large may result in excessive time and resource consumption during data collection, while a sample size that is too small may not provide sufficient data for conducting a relevant analysis. Moreover, the selection of an optimal sample size depends on the type of sampling technique utilized, and it is crucial for researchers to have confidence that the selected sample size possesses the necessary width to meet the precision requirements of a study [63][67]. Therefore, the sample size was chosen based on saturation, a stage in which a researcher determines that all the necessary data for a study have been collected, and no further relevant information or data can be obtained from the respondents or subjects involved in the research [67].

The carriers were chosen based on the limitations of this report, as mentioned in Section 1.3. In total, 6 separate interviews with transport coordinators at different carrier companies were conducted. In addition to the interviews, an online questionnaire was selected to supplement the interview results because of its time efficiency and ability to administer results effectively [62]. Furthermore, the questionnaire helped the researchers to confirm and validate the interview findings, as well as explore new categories that might be of interest. To initially gather qualitative data, and subsequently, the qualitative data is utilized to devise a questionnaire follows an exploratory mixed methods research design [65]. In total, 8 questions were formulated, see Appendix B, and the questionnaire was sent out to 967 companies within the scope of the thesis. The response rate reached 1.65%. The low response rate is a damaging limitation of an online questionnaire [68]. Increasing the number of responses would be advantageous in enhancing the reliability of the answers. Question 3 is later focused on in Section 3.2.2, while questions 4-8 were used to elicit more requirements and therefore relevant for this step. The questions were formed as open-ended, and as a result, the respondents have the potential to offer more nuanced and refined perspectives on the phenomenon being investigated [64].

The data analysis was done through a qualitative analytic method called thematic analysis. The process was done in accordance with the first 5 phases Braun and Clarke identify [69]:

1. Familiarize with the data: Read the data and make notes of potential ideas.
2. Generate initial codes: Systematically label the dataset that appears interesting.
3. Search for themes: Gather codes into themes for further analysis.

4. Review themes: Control if the themes work with the data.
5. Defining and naming themes: Refine themes and overall narrative.

Note that codes, in this thesis, correlate to customer requirements. The 6 interviews and the online questionnaire provided valuable insights where, with the use of thematic analysis, 16 different requirements were elicited and used throughout the thesis. The next step of the HoQ consists of customers deciding on the importance of each requirement through an online questionnaire, which will be presented in the following subsection.

3.2.2 Step 2: Requirements Prioritization

Activity number two is located in-between the previous and next step in the HoQ and handles requirements prioritization. This describes the importance of each requirement to customers and users [11]. Since there usually are limited resources when creating commercial software systems, the requirements have to be prioritized. In this step of the QFD process, the stakeholders determine the priorities of the requirements based on their perceived importance [11]. Further, prioritizing requirements is crucial in choosing an optimal subset of requirements to implement and resolving trade-offs later in the development process.

The requirements prioritization was done through the online questionnaire, see Appendix B. Here, question 3 was formed to achieve the purpose of this step. Despite there being several ways to rank requirements when conducting QFD research, such as Likert's Scale, 1-10, or either 1, 3, and 9 [59], this study used 0, 1, and 2. This was because the range only makes it easier for researchers to detect spans between different values, and therefore has no impact on the prioritization itself. Lastly, the result of the requirement prioritization was added to the right of each customer requirement in the HoQ. The next step of the HoQ is to elicit technical descriptors through semi-structured interviews at the case company, which will be presented in the following subsection.

3.2.3 Step 3: How

The third activity represents the ceiling of the HoQ and consists of listing technical descriptors corresponding to one or more of the requirements [61][11]. Further, these technical descriptors should act as measurable goals for customer requirements. However, since this is done within a software development environment, they refer to a quality element and therefore must not be measurable [60]. Unlike Step 1 where the customers were interviewed, separate semi-structured interviews with 3 representatives from the case company with different areas of expertise, were held, see Appendix C. The interviewees consisted of 3 representatives from the case company, namely one in operations, one product manager, and one developer. Similar to the approach taken in Step 1, the same logic was applied in determining the appropriate sampling size for this step and data analysis. The questions focused on key attributes of the TMS service and how it relates to the customers in terms of value, customer experience, and similar solutions to the current one in use. In addition, its customer base and sustainability requirements were also in focus.

In total, 14 technical descriptors were deemed significant based on the 3 interviews for the case of investigating the diffusion of technology within the carrier industry and, therefore, added to the HoQ. The next step of the HoQ is to determine the relationship between customer requirements derived from Step 1, and the technical descriptors with the help of a QFD team. This will be presented in the following subsection.

3.2.4 Step 4: Relationship Matrix

Activity four in building a HoQ is to compare the technical descriptors and customer requirements and thereafter determine their particular relationship [61]. Shrivastava propose to represent the relationships using symbols indicating weak, moderate, and strong relationships [70]. The symbols correspond to weight scores; a circle represents a score of 1, a triangle represents a score of 3, and a square represents a score of 9. If there was no relationship, the box remains empty. To maintain consistency, the current study utilizes the relationship scale of 1, 3, and 9.

This was done with 2 representatives from the case company with previous knowledge of a TMS, hereinafter referred to as a “QFD team”. The representatives are experts in different areas, namely carrier relations and product management. Michael, Johnson, and Renaghan mention that it is crucial to include input from service providers, as a freight forwarder is in the case of this study, since they possess valuable insights into the correlation between each service attribute and customer expectation [57]. Note, service attributes correlate to technical descriptors in this thesis. Furthermore, the authors argue that a QFD team consisting of service providers is better positioned to evaluate the strength of these relationships compared to a mixed group or solely researchers.

The relationship matrix was established during one meeting with the QFD team. After establishing the relationship matrix, the absolute value of each technical descriptor was calculated by summarizing the relationship weight in every column [70]. The absolute value indicates the extent of correlation between a specific technical descriptor and requirement, and it was displayed below each technical descriptor. Thereafter, the relative value was calculated by summarizing the product of each requirement’s prioritization and the relationship weight between each technical descriptor. The relative value point represents the overall score of both the requirements and the technical descriptors and is displayed at the bottom of the relationship matrix. This value provides an objective benchmark for future improvements and measurement [70]. The QFD team of this study offered valuable insights regarding the requirements provided and their correlation with the technical descriptors. The next step of the HoQ is to identify correlating technical descriptors through semi-structured interviews at the case company, which will be presented in the following subsection.

3.2.5 Step 5: Correlation Matrix

The correlation matrix facilitates the identification of technical descriptors that are dependent on one another or in conflict. By mapping the correlation between attributes, one can get a better understanding of how they relate to each other and potential tradeoffs [11]. Conflicting technical descriptors are important to identify because they lead to tradeoffs. Tradeoffs that aren't recognized or resolved often lead to unmet requirements, alterations to the design, increased costs, and a lower quality product [61]. The correlations between the technical descriptors are presented as the ceiling of the HoQ matrix. Besterfield introduces four correlations: 1) a strong positive relationship; 2) a positive relationship; 3) a negative relationship; 4) a strong negative relationship. The more positive the relationship, the stronger the positive correlation, and vice versa [61]. Further, the author notes that the four relationships are marked with the following symbols:

- A solid circle represents a strong positive relationship.
- A circle represents a positive relationship.
- An X represents a negative relationship.
- An asterisk represents a strong negative relationship.

Karlsson and Shrivastava include a neutral relationship, named "no relationship" [11][70]. This step will be included in this method to make room for technical descriptors with no correlation. In other words, this case study will follow the five different correlations in the correlation matrix proposed by Shrivastava [70].

This was done through 3 interviews in total together with the case company, where one was with a product manager, one was with a developer and one was within the operations team. First, an introduction to each technical descriptor was given, and several uncomplicated examples of correlations between general descriptors. Thereafter, the interviewee gave insights on possible correlations. Lastly, the compiled result of all interviews was validated by the case company. The last step of the HoQ is to decide on the development targets for each technical descriptor through semi-structured interviews with the case company, which will be presented in the following subsection.

3.2.6 Step 6: Development Targets

Development targets represent the degree to which the technical descriptor must be proficient in order to please the stakeholders [11]. Further, the targets serve the purpose of helping the cross-functional team to specify clear goals throughout the development process. In this report, the targets are solely based on the produced HoQ and data gathered during the project. Further, the development targets were based on a scale of 1 to 5, where 5 is regarded as the highest degree of development needed while 1 is regarded as the lowest.

Similar to Section 3.2.5, this was done through 3 interviews in total, where one was with a product manager, one was with a developer and one was within the operations team. First, the HoQ was introduced to the interviewees, and all values were presented. Thereafter, the interviewees were provided 5 minutes to analyze the values, technical descriptors, and customer requirements. Lastly, the interviewees provided valuable insights into the development targets of each technical descriptor. The data analysis of each interview was done with a thematic analysis, similar to Step 1 and Step 3.

3.3 Research Quality

An academic research study needs the following qualities to be considered of good quality: 1) systematic - the research is structured by a set of rules; 2) logical - applied logical reasoning and processes; 3) empirical - dealing with concrete data; 4) replicable - research results are verifiable by replicating the study and finding the same results [63]. Furthermore, validity is considered a quality criterion for good research and regards the integrity of the study's conclusions [68].

The interview questions were formulated by drawing from academic literature, as well as prior knowledge and research on TMS and the carrier industry. These questions were designed to account for the subjective nature of customer requirements and technical descriptors. The aim was to elicit requirements that could be translated into a HoQ framework. During the interviews, two researchers were involved - one conducted the interview while the other took notes and noted any potential follow-up questions. This division of tasks allowed for a more focused discussion, as the interviewer could concentrate on the semi-structured interview questions while the note-taker provided valuable input from the sidelines. Additionally, the interviews were recorded and reviewed afterward to supplement the notes taken during the interview process.

The questionnaire was based on academic literature, previous knowledge of the industry, and 6 interviews with carrier coordinators. Liang claims that a questionnaire connected to QFD can ensure high validity through academic literature, previous knowledge within the industry, and interviews [71]. The format of the questionnaire, being either horizontal or vertical, was also considered. Researchers prefer to not employ both a vertical and horizontal format in the same questionnaire [68]. Therefore, the questionnaire only used a vertical format. The questionnaire had a total of 8 questions, see Appendix B, and used three types of questions; (1) dichotomous, (2) odd-numbered scale, and (3) open questions. The central value "Good to have" of the odd-numbered scale made it behave like an even-numbered scale since there was no neutral choice, which implied that it forced the respondent to lean more towards the agreement or disagreement end of each item [62].

4 Results

This chapter will outline the empirical findings of the QFD approach, with each step of the HoQ methodology highlighted in respective sections. First, the 16 customer requirements elicited from 6 semi-structured interviews and the online questionnaire are highlighted. Second, the prioritization of requirements derived from the online questionnaire is presented. Third, a description of 14 technical descriptors derived from 3 interviews at the case company is introduced. Next, the relationship matrix result from the QFD team is presented. Lastly, the correlation matrix derived from 3 interviews is addressed, followed by the development targets originated from 3 interviews.

4.1 Result of Step 1: What

The objective of this step was to investigate the carriers' perspective regarding needs and expectations in a TMS. Moreover, the current features of carriers' TMS were evaluated and new requirements were elicited. Specifically, 16 customer requirements were elicited based on the online questionnaire with 16 responses and 6 semi-structured interviews, see Figure 4.1.

Route Planning															
Charging															
Battery Lifespan Management															
Goods Distribution in Equipage															
Volume and Weight Management															
Vehicle Configuration Optimization															
Order Management															
Invoice Management															
Driver Allocation															
Automatic Driver Allocation															
Deviation Management															
Data and Analytics Management															
Resource Optimization															
Real-time Update for Drivers															
Digital Freight Documents															
Fuel Cost Optimization															

Figure 4.1: State of HoQ after Step 1

The interviews conducted with various transport coordinators from different carrier companies yielded insights into the essential features that a TMS must have. Despite differences in their specific company practices, the interviewees held common views on key aspects of TMS functionality. Notably, they were all accustomed to conducting their operations manually, with limited support from IT systems. However, each of them had some level of support from a TMS, which typically included an order management system to manage their shipments. The interviewees demonstrated a reluctance to embrace electric solutions for heavy road freight transport.

The elicited customer requirements have been organized into four different categories based on themes derived from the thematic analysis and will be described in the following subsections.

4.1.1 Administrative Requirements

According to the interviews, the ability to manage orders is a critical function that a TMS must have. The interviewees argued that *Order Management* includes scheduling, entry, and tracking of orders. In addition, it was mentioned that this helps the transport coordinators to monitor order statuses, shipment locations, and delivery timelines. The interviewees mentioned that these functions can improve efficiency and reduce costs by minimizing errors and automating processes.

Based on the interviews, it was revealed that one of the key functions of a TMS is to manage the invoicing process for shipments. This is classified as *Invoice Management* hereinafter. Furthermore, it was mentioned that the TMS must possess the capability to automatically generate invoices based on both incoming and delivered orders. As explained by the interviewees, when an order is received and confirmed, the TMS should be capable of generating an invoice for that order automatically. This invoice should include all relevant details, such as pricing, taxes, and other applicable charges. Likewise, when a shipment is delivered and confirmed, the TMS should be able to generate an invoice for that shipment. The interviewees pointed out that automatically generated invoices can both save time and effort while ensuring accuracy and consistency in the invoicing process for transportation companies. In addition, the interviewees expressed that eliminating the need for manual data entry and calculations can cause the TMS to reduce the likelihood of errors, thus resulting in better financial operations.

According to the interviews, the importance of tracking progress and obtaining a business overview can be realized by utilizing data and analytics. In this thesis, this customer requirement is referred to as *Data and Analytics Management.* The interviewees argued that data and analytics can provide valuable insights into their business operations. Here, the ability to analyze data, such as shipment details, costs, and performance, can identify areas of improvement, namely inefficiencies, delays, and bottlenecks according to the interviewees. Furthermore, it was mentioned that issues can be identified as they arise, which implies that action can be taken quickly.

During the interviews, the subject of digital freight papers was covered, and the participants generally considered them as the inevitable development from paper-based freight documents. This is classified as *Digital Freight Documents* hereinafter. The majority of interviewees agreed that the current paper-based system was efficient, despite some of them expressing excitement about the potential advantages of digital documents, such as increased productivity and decreased paper waste. Therefore, the majority of the interviewees did not see an immediate need to change to digital documents. However, some interviewees acknowledged that digital documents might become more prevalent in the future as the industry continues to evolve.

4.1.2 Electric Requirements

There was disagreement among the interviewees regarding the significance of charging options and planning for electric trucks. In order to enable the broad adoption of electric trucks, those who thought it was a crucial problem underlined the necessity for an effective and dependable charging infrastructure. They thought that range anxiety issues may be reduced and electric trucks could drive farther with the aid of a well-designed and well-maintained charging network. Therefore, *Charging* is classified as a customer requirement in this thesis. For long-distance travel when there are few charging facilities, this would be extremely crucial. On the other hand, some interviewees expressed skepticism regarding the viability of electric trucks as an alternative to conventional diesel trucks. They raised issues with the expensive price of electric trucks, the short battery life, and the unreliable charging infrastructure. The interviews also concluded that diesel trucks were still the most cost-effective and practical option for long hauls and large-scale transportation. In addition, the interviewees agreed that the technology for electric trucks would continue to improve in the coming years, leading to wider adoption and more efficient charging solutions. They believed that advances in battery technology and improvements in charging infrastructure would make electric trucks more practical and affordable for carriers.

According to the majority of the interviews, the concept of battery lifespan management arouse although they had no prior knowledge of it. This customer requirement is called *Battery Lifespan Management*. The interviewees stated that this problem only concerned electric trucks, which not all of them had. However, several interviewees have experienced an increase in electric trucks and acknowledged that this becomes a significant issue in the future. Thus, the interviewees understood the need of maintaining the electric trucks' batteries effectively to ensure their long-term viability. Conversely, due to their lack of confidence in the technology, several respondents did not regard the management of battery lifespan as a significant issue and did not see the necessity for taking any special precautions to guarantee battery longevity.

4.1.3 Optimizable Requirements

Fuel is a significant expense for carriers, accounting for a substantial portion of their operating costs. Thus, *Fuel Cost Optimization* was a recurring theme in the interviews. The interviewees mentioned that carriers need to prioritize fuel efficiency to reduce their expenses, which is the reason why the use of fuel-efficient vehicles is important. In addition, route planning is a factor concerning fuel cost optimization since routes can be planned to minimize distance. Further, routes can be optimized to maximize the utilization of their vehicles, enabling them to carry more cargo on each trip, which also reduces fuel consumption.

The interviews concluded that the effective distribution of goods within cargo or transport vehicles ensures smooth and efficient operations. This customer requirement is called *Goods Distribution in Equipage* in this thesis. In addition, it was mentioned that proper volume and weight management of goods is important to avoid overloading or under-utilizing the transport vehicle, which can result in inefficiencies and unnecessary costs. This customer requirement is classified as *Volume and Weight Management* hereinafter. Moreover, complying with regulatory requirements is essential for carriers and transportation companies. This is because there are set specific rules and regulations related to the weight and volume of goods that can be transported, which vary depending on the type of vehicle, the type of goods, and the route. Non-compliance with these regulations can result in fines and penalties, as well as potential safety hazards for drivers and other road users.

During the interviews, the interviewees shared a common viewpoint regarding *Resource Optimization*: Transport coordinators could manage their resources more effectively than any software, as they had significant experience in the field. In this thesis, this customer requirement is referred to as *Resource Optimization.* As a result, the need for *Resource Optimization* was perceived to be relatively low, but the interviewees acknowledged that it could be essential in certain scenarios. The interviewees valued the human element in the process, as transport coordinators can make decisions based on their knowledge and expertise. However, the interviewees also recognized that software can provide useful insights and support to transport coordinators when making resource optimization decisions.

4.1.4 Executional Requirements

During the interviews, it was stressed that *Deviation Management*, which entails dealing with unforeseen occurrences and conditions that might interrupt cargo delivery, is an important component of the TMS. The interviewees gave the following examples of deviations: Traffic jams, time slot modifications, damaged goods, or goods that are not available on time. In addition, traffic bottlenecks and transportation-related concerns are typical reasons for variations in cargo delivery plans, and such delays might result in late delivery, affecting the entire supply chain. Furthermore, when there are damaged goods, the delivery procedure may be delayed while the shipping company replaces or repairs the damaged products. The interviewees underlined that in order to effectively manage deviations, they must be carefully monitored and managed in order to reduce their influence on the supply chain. A strong system for tracking and reporting deviations is essential because it enables carriers to resolve problems quickly and keep communication open with customers.

According to the interviews, it was established that *Route Planning* is a customer requirement. The interviewees stressed that finding the optimal route for a delivery is important because of the fuel cost. In addition, the interviewees stated that the vehicle utilization can be optimized by *Route Planning* by enabling them to carry more cargo on each trip. Further, it was mentioned that *Route Planning* can be utilized to minimize transportation costs in general.

The interviews concluded that *Real-time Updates for Drivers* is important for managing unexpected delays, such as changes in delivery times, locations, and other factors that could affect the driver's performance, during a delivery. One interviewee gave the example, if a driver is on the way to a delivery location and encounters a traffic jam or other issues, *Real-time Updates for Drivers* can provide the driver with alternative routes or delivery options. This enables the driver to make adjustments and ensure timely delivery of goods. Moreover, the interviewees concluded that *Real-time Updates for Drivers* can help to manage their time more efficiently by prioritizing their tasks and allocating their time more effectively.

During the interviews, the importance of *Vehicle Configuration Optimization* was discussed. The interviewees believed that, similar to *Resource Optimization*, *Vehicle Configuration Optimization* could be handled better by experienced transport coordinators than by software. The interviewees recognized that efficient vehicle configuration has the ability to increase the effectiveness of transportation and minimize costs. Therefore, *Vehicle Configuration Optimization* is a customer requirement in this thesis. The interviewees emphasized the importance of proper weight distribution, managing cargo volume, and the selection of vehicles depending on transportation tasks.

According to the interviews, it became clear that *Driver Allocation* was considered to be a critical task in the transportation industry. Allocating drivers to specific routes and vehicles is important for the efficient and timely delivery of goods. The interviewees expressed skepticism about the software solution's effectiveness regarding this matter. In particular, it was believed that the software could not match the decision-making ability of experienced transport coordinators, who could take into account various factors such as driver availability, expertise, and familiarity with the delivery routes. The reliance on human decision-making was a common theme across all carrier companies that were interviewed. While software tools were used to support transport coordinators, the final decision regarding *Driver Allocation* was ultimately made by a human. The importance of *Driver Allocation* in ensuring timely and efficient deliveries cannot be understated, and interviewees emphasized the need for experienced coordinators to handle this task.

The transport coordinator had manual processes for allocating drivers, trucks, and trailers to a specific shipment, as well as managing incoming orders according to the interviews. The reason was consistent among the interviewees: To adhere to deviations and to stay flexible, humans are required rather than rigid IT solutions.

One of the reasons was summarized by one of the respondents: “Software does not have the experience of an experienced transport coordinator”. In the transport industry, there are many variables that are changing on a daily basis (e.g. new time slots, traffic, waiting times, breakdowns, etc.). This makes the daily operations unpredictable, which forces transport carriers and their coordinators to be flexible and proactive in the way they manage their operations. All interviewees claim that there is no system that can be proactive and flexible enough to handle their operations. In other words, manual labor is necessary in order for the operations to work accordingly.

By contrast, one transport coordinator argued that transport planning can be done by software with the precondition that it is a small and rigid operation that does not frequently change. For larger and more common transport needs, the consensus was clear: In order to plan, the planner needs experience. To be able to plan an operational system of many employees, trucks, trailers, and more orders, one needs to have all available information to make decisions. The transport coordinators claimed that software planning tools seldom could handle information as the transport coordinator can. Therefore the coordinator could make better decisions, making the planning software obsolete.

The practice of conducting driver allocation automatically via a software system was described as *Automatic Driver Allocation* in the study, which distinguished between the two terms. The interviewees discussed the difficulties of putting into practice an autonomous driver allocation system. In detail, it was observed that it is challenging to forecast and assign drivers for each work since the transportation sector encounters several unexpected occurrences on a regular basis. The interviewees concluded that manual driver allocation offers better flexibility and reactivity to unanticipated events, making it a more dependable choice. The interviewees also emphasized the significance of the transport coordinator’s role in driver allocation because they have the expertise and knowledge needed to make wise decisions and deal with unforeseen situations.

4.2 Result of Step 2: Requirements Prioritization

This section presents the result of the customer prioritization from the questionnaire where 16 requirements have been rated on a scale of 0, 1, and 2. Here, the highest number indicates the most important. Moreover, 16 responses were collected from carriers with different levels of responsibility across Scandinavia. The result of the data collected through the questionnaire is presented in Figure 4.2. Additionally, the responses from 16 respondents were used to calculate an average score for every customer requirement.

Customer Requirements:	RQ1	RQ2	RQ3	RQ4	RQ5	RQ6	RQ7	RQ8	RQ9	RQ10	RQ11	RQ12	RQ13	RQ14	RQ15	RQ16
Respondent 1	1	2	2	2	2	1	2	2	2	2	2	1	1	1	0	2
Respondent 2	1	2	1	1	0	1	0	0	0	1	1	0	0	1	0	2
Respondent 3	2	2	2	2	2	2	1	2	0	2	2	2	1	2	1	2
Respondent 4	2	0	0	1	1	2	2	0	2	2	2	2	2	1	1	1
Respondent 5	1	1	1	1	1	2	1	2	2	2	2	1	1	0	0	1
Respondent 6	2	2	2	2	2	0	1	2	2	1	1	2	0	1	1	1
Respondent 7	1	0	0	2	2	1	1	1	1	2	2	0	1	1	2	0
Respondent 8	1	2	2	1	1	2	1	2	2	2	2	1	1	1	2	2
Respondent 9	2	2	1	2	2	1	0	0	0	2	2	2	0	1	2	1
Respondent 10	2	0	0	1	1	1	1	1	1	2	2	1	1	1	1	0
Respondent 11	1	2	2	1	1	2	1	2	2	1	1	1	1	1	1	0
Respondent 12	0	1	1	1	1	0	2	0	0	2	2	1	2	1	2	2
Respondent 13	1	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1
Respondent 14	1	0	0	2	1	2	1	1	1	1	2	0	0	1	0	1
Respondent 15	1	0	0	1	1	1	0	1	1	0	2	0	0	2	0	2
Respondent 16	1	0	0	2	1	0	1	1	1	2	2	1	1	1	1	1
Average	1.30	1.10	0.90	1.40	1.30	1.20	0.90	1.10	1.10	1.60	1.80	0.90	0.80	1.10	0.90	1.20

RQ1: Route Planning
RQ2: Charging
RQ3: Battery Lifespan Management
RQ4: Data and Analytics Management
RQ5: Deviation Management
RQ6: Real-time Update for Drivers
RQ7: Goods Distribution in Equipage
RQ8: Volume and Weight Management
RQ9: Vehicle Configuration Optimization
RQ10: Order Management
RQ11: Invoice Management
RQ12: Driver Allocation
RQ13: Automatic Driver Allocation
RQ14: Resource Optimization
RQ15: Digital Freight Documents
RQ16: Fuel Cost Optimization

Figure 4.2: Customer prioritization of requirements

The requirements were ranked according to the following: *Invoice Management* received the highest score with 1,8 and is, therefore, the most important requirement. *Order Management* earned a score of 1,6. *Data and Analytics Management* obtained a score of 1,4. Subsequently, *Deviation Management* got a score of 1,3 and was classified as the fourth most important requirement according to the customers. In agreement with the customers, both *Real-time Update for Drivers* and *Fuel Cost Optimization* received a score of 1,2, which implies them being equally important. Moreover, *Charging*, *Volume and Weight Management*, *Vehicle Configuration Optimization*, and *Resource Optimization* received a score of 1,1. *Battery Lifespan Management*, *Goods Distribution in Equipage*, *Driver Allocation*, and *Digital Freight Documents* received a score of 0,9. Lastly, *Automatic Driver Allocation* received a score of 0,8 and is therefore classified as the least important customer requirement.

4.3 Result of Step 3: How

The aim of this step was to explore technical descriptors that correspond to the elicited requirements and facilitate their implementation. Here, 14 technical descriptors based on 3 semi-structured interviews with the case company will be described, see Figure 4.3.

		Geographical Information System	Tachograph data	e-CMR	Dispatch System	Business Intelligence System	Regulation Management	Scheduling Tool for Drivers	Fleet Management Data	Billing and Payment Data	Cargo Property	Load Capacity	Static Hardware Properties	Telematics Data	Order Analysis
Route Planning	1.3														
Charging	1.1														
Battery Lifespan Management	0.9														
Goods Distribution in Equipage	1.1														
Volume and Weight Management	1.1														
Vehicle Configuration Optimization	1.1														
Order Management	1.6														
Invoice Management	1.8														
Driver Allocation	0.9														
Automatic Driver Allocation	0.8														
Deviation Management	1.3														
Data and Analytics Management	1.4														
Resource Optimization	1.1														
Real-time Update for Drivers	1.2														
Digital Freight Documents	0.9														
Fuel Cost Optimization	1.2														

Figure 4.3: State of HoQ after Step 3

The technical descriptors have been organized into three different categories based on themes derived from the thematic analysis and will be described in the following subsections.

4.3.1 Administrative Technical Descriptors

The interviews concluded that *Order Analysis* is a technical descriptor that must be taken into account. *Order Analysis* involves analyzing the incoming order and is important for optimizing the allocation of resources, including vehicles, drivers, and equipment. The information that can be analyzed is, according to the interviewees, the volume and priority of orders. Furthermore, it was also mentioned that it can enable the identification of potential issues or delays in the delivery process, which can be addressed proactively.

Based on the interviews, it can be concluded that *e-CMR* is a technical descriptor. *e-CMR* was explained as an electronic version of the traditional paper consignment note that is used in the transportation of goods that allows companies to create, transmit, and store consignment notes electronically, reducing paperwork and manual errors. Moreover, it was stated that *e-CMR* aids companies in meeting regulatory requirements for consignment notes, and ensures a more efficient way of exchanging information between the different parties involved in the delivery process.

According to the interviews, *Regulations Management* is a technical descriptor. This is due to its role in ensuring the safety and compliance of drivers and carriers. The interviewees stated that there are laws and regulations that need to be followed, such as hours-of-service regulations, and weight restrictions. Furthermore, it was mentioned that non-compliance with these regulations can lead to significant penalties, including fines, and license suspension. Further, this ensures that carriers follow best practices and industry standards.

The interviews concluded that *Billing and Payment Data* is a technical descriptor. The interviewees stated that this information entails keeping track of the bills, payments, and other financial dealings associated with transport activities. In the context of the transport industry, it was mentioned that this data is important for managing and tracking payments for transportation services provided by carriers, shippers, and logistics providers. One interviewee mentioned that *Billing and Payment Data* is used for enabling automated billing and invoice administration, which also contributes to reducing mistakes made by human error.

The technical descriptor *Business Intelligence System* was identified based on the interviews. *Business Intelligence System* refers to the process of collecting, analyzing, and presenting data. This involves, according to the interviews, the use of various tools and technologies to extract insights from raw data, which can be used to identify patterns and trends. Furthermore, the interviewees mentioned that *Business Intelligence System* is used by organizations of all sizes, not only carriers, to support decision-making and improve business performance.

4.3.2 Static and Dynamic Technical Descriptors

The interviews also revealed that a TMS need to take *Static Hardware Properties* into consideration. This refers to the physical characteristics and specifications of equipment, such as its size, weight, and capacity, which do not change over time. Moreover, this is directed to equipage where its attributes are of importance. This is because the attributes of equipage, such as its weight capacity and fuel efficiency, are crucial factors in transportation management. According to the interviewees, the TMS can accurately calculate the optimal load for a shipment when taking it into account. Connected to physical characteristics and specifications of equipages, the interviews revealed two additional technical descriptors: *Load Capacity* and *Cargo Properties*. First, *Load Capacity* is based on how much goods the carriers can load, which the interviewee considered a key functionality of their TMS since it is important to have a transportation flow plan for each corresponding assignment. Further, it becomes increasingly important to plan this depending on the size of their fleet and orders. Second, *Cargo Properties* was discussed based on the TMS' ability to adjust specific shipments based on the description of the mission. This implies that the TMS can tailor the trucks based on the specifics of the mission.

Based on the interviews, it was concluded that *Tachograph Data* holds significant importance as a technical descriptor due to the valuable data that can be obtained from it. *Tachograph Data* refers to the information that is recorded by a tachograph device, which is a type of electronic logging system that is commonly used in trucks to monitor the driving behavior of the driver. The device records various parameters related to driving, including driving time, speed, distance traveled, and rest periods of the driver. *Tachograph Data* can provide insights into the efficiency of the driver, as well as compliance with legal regulations related to driving and rest times. For instance, the interviewees mentioned that the data can be used to track and manage the working hours of the driver to ensure they are not exceeding legal limits for driving time, which can help to prevent accidents caused by driver fatigue. In addition to this, *Tachograph Data* can also be used to optimize fleet management, improve fuel efficiency, and reduce maintenance costs.

According to the interviews, *Telematics Data* is a technical descriptor. This is due to trucks employing telematics systems to gather and use data, including location, speed, fuel usage, and engine performance. The interviewees mentioned that *Telematics Data* can give insights into fleet operations, helping carriers to increase their efficiency. Further, by evaluating *Telematics Data*, carriers can find areas of improvement, for instance, vehicle maintenance and route optimization.

The interviews revealed that *Fleet Management Data* is a technical descriptor. *Fleet Management Data* was explained by the interviewee as a collection of information related to the management and operation of a fleet of vehicles. This data includes details about the vehicles, such as their location and status. By analyzing *Fleet Management Data*, transport coordinators can make decisions about route planning, vehicle utilization, and maintenance scheduling. The interviewees emphasized that real-time *Fleet Management Data* is particularly valuable, as it allows for timely intervention in case of any issues or unexpected events.

4.3.3 Executional Technical Descriptors

Based on the interviews, the most commonly discussed was the *Dispatch System*. Here, the traditional concept of a dispatch system that handles automate routing and scheduling procedures, was not implied by the interviewees. Instead, the ability to customize how messages are sent and created was the focus of a dispatch system as a technical descriptor in this context. This allows the coordinator and driver to tailor their communication to specific needs and requirements. The interviews also conclude that the dispatch system also can connect to other systems, such as GPS, and the ability to send messages to a driver or a specific truck.

Due to its function in organizing the routes for the drivers, it was discovered during the interviews that *Geographical Information System* (GIS) is a technical descriptor that must be taken into consideration. *Geographical Information System* allows businesses to map out the locations of their drivers and customers as well as the routes to reach them. *Geographical Information System* capture, store, manage, and presents data that are linked to geographic locations. With the use of *Geographical Information System*, businesses get real-time information on traffic patterns, road closures, and other occurrences that can hinder delivery. Therefore, it is important for companies to integrate *Geographical Information System* into their routing and scheduling processes to ensure efficient delivery operations.

Based on the interviews, it was concluded that a *Scheduling Tool for Drivers* is a technical descriptor in this study. The reason for this is that it is necessary to know the availability of drivers while optimizing and planning resources. Additionally, there are regulatory compliances that transport coordinators need to adhere to while planning driver shifts. According to the interviewees, a *Scheduling Tool for Drivers* is a software application used in the transport industry to manage and plan driver schedules, which allows transport coordinators to create and assign shifts for drivers based on their availability, driving hours, and other regulatory compliances. This tool helps optimize the allocation of drivers to specific routes and vehicles, ensuring that delivery schedules are met efficiently and within legal limits. The scheduling tool can also track driver performance, including driving time, rest periods, and other factors that impact productivity and safety.

4.4 Result of Step 4: Relationship Matrix

This section presents the result of the relationship between the technical descriptors and customer requirements, which was done through an interview with the QFD team, see Figure 4.4. In addition, the absolute value and relative value of each technical descriptor are presented. The findings will be presented in three organized sections. First, all relationships that received a strong relationship will be presented. Second, all medium relationships will be introduced, and third, all weak relationships. Furthermore, all relationships that are evidently clear to conclude will not be discussed in detail.

		Geographical Information System	Tachograph data	e-CMR	Dispatch System	Business Intelligence System	Regulation Management	Scheduling Tool for Drivers	Fleet Management Data	Billing and Payment Data	Cargo Property	Load Capacity	Static Hardware Properties	Telematics Data	Order Analysis
Route Planning	1.3	□			□	△	△	□	△			□	□		□
Charging	1.1	○			○			□	□	△			□	□	
Battery Lifespan Management	0.9					○							□	□	
Goods Distribution in Equipage	1.1				○	△					□	□			△
Volume and Weight Management	1.1			○	○	△	□				□	□			△
Vehicle Configuration Optimization	1.1				○		□				□	□	□		□
Order Management	1.6				□	△		△		□	△	△			□
Invoice Management	1.8		△	△		□				□				△	
Driver Allocation	0.9		□		□		□	□	□						
Automatic Driver Allocation	0.8		□		□		□	□	□						
Deviation Management	1.3			△	□	△		○		△					
Data and Analytics Management	1.4					□			□	○		○	○	□	□
Resource Optimization	1.1				□			□	□				□		
Real-time Update for Drivers	1.2		□		□		□	○						○	
Digital Freight Documents	0.9		□	□	□						□				
Fuel Cost Optimization	1.2	○	○		△	□		△			○		□	□	
Absolute Value		11	40	16	79	43	48	53	48	26	40	40	55	40	42
Relative Value		14	41	19	90	60	50	57	52	39	44	48	72	48	55

Figure 4.4: State of HoQ after Step 4

4.4.1 Strong Relationship

The customer requirement *Route Planning* has, according to the QFD team, a strong relationship with *Geographical Information System*. This is because *Geographical Information System* handles the necessary functions and stores the needed data to facilitate *Route Planning* for a TMS. Further, *Route Planning* was considered to have a strong relationship with *Dispatch System* since the QFD team argued that messages considering deviations that might occur because of unforeseen events might result in re-routing. *Route Planning* and *Scheduling Tool for Drivers* were also considered to have a strong relationship because the planning of routes needs to take driver shifts into account. The following example was given: a driver cannot start a route that exceeds his/her shift. Furthermore, the QFD team argued that to efficiently manage your deliveries, it is crucial to have knowledge of the orders assigned to a particular truck or route. This is the reason for the strong relationship between *Route Planning* and *Order Analysis.* Equally important, according to the QFD team, is to determine the maximum *Load Capacity* of the vehicle. Additionally, it is possible to perform both loading and unloading while the truck is on a route. Hence, to accommodate any new orders while in operation, it is important to be aware of the available capacity.

The QFD team agreed to put a strong relationship between *Charging* and both *Scheduling Tool for Drivers* and *Fleet Management Data* since it is important to optimize driving times in a way that minimizes the frequency and duration of standstill due to charging. Moreover, the QFD team mentioned that this has a cost-effective benefit on the battery, and therefore, economic benefits. Furthermore, *Charging* is considered, according to the QFD team, to have a strong relationship with *Static Hardware Properties* because it is highly dependent on each other. The QFD team also put a strong relationship between *Charging* and *Telematics Data* since it can provide important data such as location and state of charge. The QFD team also argued that *Battery Lifespan Management* has a strong relationship with both *Static Hardware Properties* and *Telematics Data* for the same reason.

According to the QFD team, *Goods Distribution in Equipage* has a strong relationship with *Cargo Property* and *Load Capacity.* The QFD team notes that these technical descriptors are crucial for a TMS to calculate the optimal distribution of goods during loading. The interview concluded that carriers can ensure the optimization of their loading processes through this relationship. Additionally, the QFD team found that two other customer requirements, *Volume and Weight Management*, and *Vehicle Configuration Management*, also have a strong relationship with *Cargo Property* and *Load Capacity.* Similarly, this is because these technical descriptors are also important factors in calculating the optimal distribution of goods during loading. Based on the interview, it was concluded that carriers can balance their loads and comply with weight restrictions accordingly by utilizing these relationships

The QFD team also noted that *Volume and Weight Management* has a strong relationship with *Regulation Management.* This is because carriers must comply with laws regarding truck weight. Similarly, *Vehicle Configuration Management* has a strong relationship with *Regulation Management.* Instead of truck weight, carriers must comply with regulations regarding the configuration of their vehicles, such as maximum length and width. Furthermore, the QFD team noted that *Vehicle Configuration Management* has a strong relationship with *Order Analysis.* This is because the TMS can, based on the order and vehicle, determine the most efficient way to transport goods while meeting customer requirements.

The QFD team identified a strong relationship between *Order Management* and *Dispatch System*. This was concluded by the need for real-time updates on the delivery status or reporting any issues that may arise during the delivery process. Further, the QFD team noted that *Invoice Management* has a strong relationship with *Business Intelligence System*. The QFD team argued that this relationship exists due to the possibility of extraction and analysis of data related to billing and payments, which can result in reduced payment delays and an improved billing process.

The QFD team also agreed to insert a strong relationship between *Driver Allocation* and *Tachograph Data*. This is a result of the combination of these where driver allocation can be optimized, which implies that carriers can improve their operational efficiency. Further, *Scheduling Tool for Drivers* also has a strong relationship with *Driver Allocation* according to the QFD team. This is because the availability of drivers is dependent on their current schedule. This is also linked to why the *Regulation Management* received a strong relationship with *Driver Allocation* by the QFD team, where the carriers must adhere to regulatory compliance regarding work hours. The QFD team also put a strong relationship between *Driver Allocation* and *Fleet Management Data* since the availability of vehicles must be taken into consideration. As *Driver Allocation* and *Automatic Driver Allocation* are sharing the same key functionality, the QFD team used similar reasoning for their strong relationships. Further, the QFD team argued that *Deviation Management* has a strong relationship with *Dispatch System*. This is due to a message that must be sent by the TMS to the driver which informs the driver about the situation if deviations occur while the driver is on the route.

The QFD team concluded a strong relationship between *Data and Analytics Management* and *Business Intelligence System* because it allows carriers to leverage the power of data to drive their business decisions. By integrating Data and Analytics Management with *Business Intelligence System*, carriers can gather, analyze, and utilize valuable data to optimize their operations, improve their services, and meet the demands of their customers. Further, the QFD team identified a strong relationship between *Data and Analytics Management* and *Fleet Management Data* since it has the possibility to enable carriers to leverage the power of data to optimize fleet performance and therefore reduce costs. Similarly, the QFD team also found a strong relationship between *Data and Analytics Management* and *Telematics Data* using the same reasoning. However, the QFD team added that a combination of these two can also increase customer service. *Automatic Driver Allocation* and *Fleet Management Data* have a strong relationship according to the QFD team because the allocation system needs to have information about the available fleet at all times in order to efficiently allocate the fleet to all incoming orders. Furthermore, *Data and Analytics Management* has a strong relationship with *Order Analysis* according to the QFD team. This is due to that it enables carriers to gain valuable insights into their customers' ordering patterns and preferences, which can be used to optimize their operations.

4.4.2 Medium Relationship

According to the QFD team, *Route Planning* has a medium relationship with *Business Intelligence System* since it has the possibility to analyze route-specific data, which can provide benefits for carriers. In addition, the QFD team concluded that *Goods Distribution in Equipage* and *Volume and Weight Management* also have a medium relationship with *Business Intelligence System* due to the possibility to analyze specific data on the management of goods distribution, and volume and weight management. Furthermore, *Distribution in Equipage* and *Volume and Weight Management* also shared a medium relationship with *Order Analysis* since it can be used to plan each shipment for carriers. Moreover, the QFD team argued that *Order Management* also had a medium relationship with *Business Intelligence System* since it has the possibility to identify areas for improvement in their order management processes. An instance where it can be useful is in analyzing order fulfillment times to detect potential bottlenecks in the process. This can enable carriers to make necessary modifications to improve overall efficiency. *Route Planning* and *Regulations Management* were deemed to have a medium relationship due to the role regulations have in the routes the vehicles drive. The QFD team mentioned that specific trucks are not allowed on all roads and the route planning system needs to be able to take this into consideration.

Furthermore, the QFD team concluded that *Order Management* has a medium relationship with *Scheduling Tool for Drivers* because it is necessary to know the availability of resources in order to plan orders. Moreover, *Order Management* has a medium relationship with both *Cargo Properties* and *Load Capacity* according to the QFD team. This is because this data can be used to plan each shipment that the carriers will conduct, and also plan for incoming goods. The QFD team asserts that *Invoice Management* has a medium relationship with *Tachograph Data* because invoices can be based on the distance driven by the carriers. Similarly, *Invoice Management* also has a medium relationship with *Telematics Data* according to the QFD team because of the same reason. In addition, *Telematics Data* can be used to verify the invoice. Furthermore, the QFD team concluded that *Invoice Management* has a medium relationship with e-CMR since invoicing can be charged by weight or volume, which one can retrieve from the e-CMR.

Deviation Management has three medium relationships according to the QFD team. First, *e-CMR* since there may be a discrepancy between what is booked in the order and what is delivered, which can be confirmed by *e-CMR*. Second, *Business Intelligence System* since deviations can be analyzed in order for carriers to learn and be proactive in their operations. Third, *Billing and Payment Data* and *Deviation Management* have a medium relationship due to the role deviations have in managing billing and payments. The QFD team claimed that the TMS needs to be able to adjust the billing and payment handling based on deviations. Furthermore, the QFD team concluded that *Fuel Cost Optimization* has a medium relationship with *Dispatch System* since the driver can receive feedback via the dispatch system about consumption and efficiency, which can affect fuel cost.

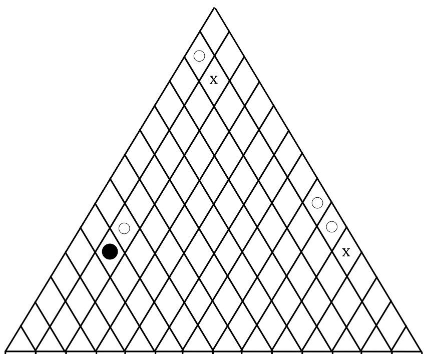
4.4.3 Weak Relationship

According to the QFD team, *Charging* has two weak relationships: *Geographical Information System* and *Dispatch System.* The former is because, in order to create a charging plan, the system needs to know where the chargers are located. The geographical location of the chargers is information that can be obtained through a *Geographical Information System.* There is also a relationship between *Charging* and *Dispatch System.* The reason is the fact that the drivers need to get input from the system where they ought to charge. As defined in this report, a dispatch system feeds the driver information from the TMS automatically or manually through the transport coordinator, and the other way around (information going from the drivers to the transport coordinators or into the system). *Battery Lifespan Management* and *Business Intelligence System* also have a weak relationship because it was concluded by the QFD team that there needs to be a *Business Intelligence System* in place in order to maximize the lifespan of the batteries. The reason is that there needs to be a system that can analyze all factors that are important for a battery and then provide guidelines to the users for the optimum handling of the hardware. *Goods Distribution in Equipage* and *Dispatch System* also have a weak relationship because the drivers need to know where all the goods are placed in the truck and/or trailer. If not, it can take a lot of time for the drivers to find specific goods, which could affect the operational performance.

Volume and Weight Management has, according to the QFD team, a weak relationship with both *e-CMR* and *Dispatch System.* The reason is that the *e-CMR* is a receipt of exactly what has been loaded on the truck. Therefore, it is an important component of volume and weight management. Regarding the *Dispatch System*, it has a weak relationship with *Volume and Weight Management* because the drivers need to know the volume and weight restrictions of the equipage that they are operating. According to the QFD team, today, this type of information is often passed along between the drivers and coordinators by word of mouth. In this regard, a *Dispatch System* could benefit knowledge sharing and minimize the risk of regulatory missteps. *Vehicle Configuration Optimization* and *Dispatch System* have a weak relationship because the drivers need to get the information on which equipage to operate. This is handled by the transport coordinator today and often handled by phone, according to the QFD team, but can also be handled through a dispatch system. *Deviations Management* and *Scheduling Tool for Drivers* have a weak relationship for two reasons. For one, potential deviations in the operations can lead to deviations in the schedule. Conversely, deviations in the schedule can lead to deviations in the operational setup.

4.5 Result of Step 5: Correlation Matrix

The Correlation matrix serves as the top roof of the HoQ matrix, depicting the relationships among various technical descriptors. This was constructed by utilizing insights gained from 3 interviews with the case company. As mentioned in Section 3.2.5, five symbols were used in the matrix to indicate positive, strong positive, negative, and strong negative correlations, while a blank field indicates no correlation, see Figure 4.5.



		Geographical Information System	Tachograph Data	e-CMR	Dispatch System	Business Intelligence System	Regulation Management	Scheduling Tool for Drivers	Fleet Management Data	Billing and Payment Data	Cargo Property	Load Capacity	Static Hardware Properties	Telematics Data	Order Analysis
Route Planning	1.3	□			□	△	△	□	△			□	□		□
Charging	1.1	○			○			□	□	△			□	□	
Battery Lifespan Management	0.9					○							□	□	
Goods Distribution in Equipage	1.1				○	△					□	□			△
Volume and Weight Management	1.1			○	○	△	□				□	□			△
Vehicle Configuration Optimization	1.1				○		□				□	□	□		□
Order Management	1.6				□	△		△		□	△	△			□
Invoice Management	1.8		△	△		□				□				△	
Driver Allocation	0.9		□		□		□	□	□						
Automatic Driver Allocation	0.8		□		□		□	□	□						
Deviation Management	1.3			△	□	△		○		△					
Data and Analytics Management	1.4					□			□	○	○		○	□	□
Resource Optimization	1.1				□			□	□				□		
Real-time Update for Drivers	1.2		□		□		□	○						○	
Digital Freight Documents	0.9		□	□	□						□				
Fuel Cost Optimization	1.2	○	○		△	□		△			○		□	□	
Absolute Value		11	40	16	79	43	48	53	48	26	40	40	55	40	42
Relative Value		14	41	19	90	60	50	57	52	39	44	48	72	48	55

Figure 4.5: State of HoQ after Step 5

As visualized in Figure 4.5, there are a large number of technical descriptors that have neutral correlations. The interviews concluded that the majority of technical descriptors have a neutral correlation. These descriptors are not necessarily related to each other and may have no impact on each other, leading to neutral correlations. This was explained by the complexity of the systems where multiple technical descriptors were used to describe different aspects of the system. Nevertheless, it is important to identify neutral correlations to know whether they can be developed independently. Based on the interviews, some of the technical descriptors required communication and data exchange with others but the correlation between them was still classified as neutral.

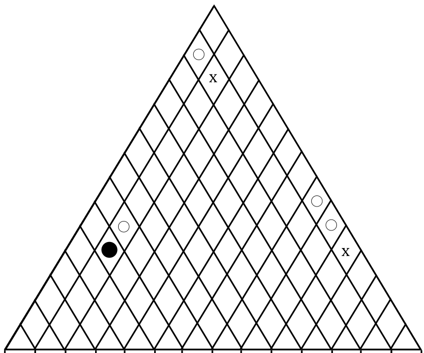
Apart from the neutral relationships, positive correlations were the most frequently observed. According to the interviews, there was one strong positive relationship between Tachograph Data and Regulatory Management. The reason for the strong positive relationship was that there cannot be one without the other. Two interviewees mentioned that Tachograph Data is obligatory in the EU and is a large part of the regulatory management that a carrier needs to adhere to. In other words, it was found that there are synergies and overlaps between the two technical descriptors, and the relationship was therefore considered to be strong.

The interviews determined that there are four positive correlations between the technical descriptors. First, one correlation is between *Geographical Information System* and *Telematics Data*, because the *Geographical Information System* stores and analyses its data. Therefore, there is a positive synergy effect between the two technical descriptors. There is also a positive correlation between *Tachograph Data* and *Scheduling Tool for Drivers*. As the tachograph includes driver-specific data, it can be used by the scheduling tool to optimize routes and plan rest periods. Based on the interviews, it was also determined that there was a positive relationship between *Fleet Management Data* and *Order Analysis*. The reason for this is that in order for the order analysis to be able to determine if, for example, an order can be accepted, the decision needs to be made in accordance with the status of the fleet. Accepting an order is not possible if there is no available fleet. Therefore, the decision-making needs to incorporate these two technical descriptors in order for efficient order analysis and operations. The last correlation is between *Billing and Payment Data* and *Order Analysis*. Based on the interviews, it was found that invoicing in most modern systems is generated automatically. In order for that feature to exist, there needs to be a basis for the invoicing in the form of data about the services that are being invoiced. *Order Management* can serve as the basis for invoicing and can therefore be considered to have a positive correlation with billing and invoicing.

In terms of negative relationships between the technical descriptors, there were only two: 1) *Tachograph Data* and *Telematics Data*, and 2) *Cargo Property* and *Order Analysis*. Focusing on (1), it was considered to be a negative correlation because some specific data points could only be taken from one of the two technical descriptors. Distance driven, for example, can only be taken from one of the two descriptors, meaning that there is no positive synergy between the two. As for (2), the data from only one of the two descriptors can be used for certain data points. The rationale was that the cargo property data only could be given from one of the two descriptors. *Cargo Property*, however, is, as a descriptor, not specific and rather broadly specified in this thesis. Data points for this descriptor could, for example, come from a packing list or a phone call or e-mail from the shipper, while the data point from *Order Analysis* comes from the formal order from the shipper. Therefore, there are different ways of getting the character of the goods. This resulted in a negative correlation, according to the interviews, due to the fact that the data has to be gathered from either one of the technical descriptors, and consequently, there are no synergies between them.

4.6 Result of Step 6: Development Targets

This section presents the level of proficiency required in the technical descriptors to satisfy the stakeholders. The result of the 3 interviews is presented in Figure 4.6.



		Geographical Information System	Tachograph data	e-CMR	Dispatch System	Business Intelligence System	Regulation Management	Scheduling Tool for Drivers	Fleet Management Data	Billing and Payment Data	Cargo Property	Load Capacity	Static Hardware Properties	Telematics Data	Order Analysis
Route Planning	1.3	□			□	△	△	□	△			□	□		□
Charging	1.1	○			○			□	□	△			□	□	
Battery Lifespan Management	0.9					○							□	□	
Goods Distribution in Equipage	1.1				○	△					□	□			△
Volume and Weight Management	1.1			○	○	△	□				□	□			△
Vehicle Configuration Optimization	1.1				○		□				□	□	□		□
Order Management	1.6				□	△		△		□	△	△			□
Invoice Management	1.8		△	△		□				□				△	
Driver Allocation	0.9		□		□		□	□	□						
Automatic Driver Allocation	0.8		□		□		□	□	□						
Deviation Management	1.3			△	□	△		○		△					
Data and Analytics Management	1.4					□			□	○		○	○	□	□
Resource Optimization	1.1				□			□	□				□		
Real-time Update for Drivers	1.2		□		□		□	○						○	
Digital Freight Documents	0.9		□	□	□						□				
Fuel Cost Optimization	1.2	○	○		△	□		△			○		□	□	
Absolute Value		11	40	16	79	43	48	53	48	26	40	40	55	40	42
Relative Value		14	41	19	90	60	50	57	52	39	44	48	72	48	55
Development Target		5	3	3	5	5	2	3	3	2	2	3	3	3	4

Figure 4.6: State of HoQ after Step 6

The interviews concluded three technical descriptors that got a score of 5. First, *Geographical Information System*, despite its low relative value, can not provide errors regarding the route since it concerns the core business of carriers. Second, *Dispatch System* since it has the highest relative score out of all technical descriptors. Third, *Business Intelligence System* since it has strong relationships with important customer requirements such as *Invoice Management* and *Data and Analytics Management*. Further based on the interviews, *Order Analysis* received a score of 4 due to its strong relationships with highly prioritized customer requirements, such as *Route Planning*, *Order Management*, and *Data and Analytics Management*.

According to the interviews, *Tachograph Data* received a score of 3 due to its value to generate driver-specific data. Next, *e-CMR* also received a score of 3 despite it not having much relative score. The reason was that it does not need to be perfect to work accordingly. Furthermore, the interviews concluded a score of 3 on *Scheduling Tool for Drivers* because of its high relative score. Similarly, *Static Hardware Data* and *Telematics Data* also received a score of 3 because of the same reason. Further, the interviewees argued that it does not need to be focused on to create a large impact on the carrier's operation. *Fleet Management Data* and *Load Capacity* also received a score of 3 based on the interviews. This is due to its importance for the delivery of goods and planning. Lastly, the interviews concluded that *Billing and Payment Data* and *Cargo Properties* got the lowest score among all technical descriptors with a score of 2, mainly as a result of these being generic and static data.

5

Discussion

This chapter will analyze and discuss the data collected in relation to the literature review. First, the customer requirements and their prioritization connected to the literature will be discussed. This will indicate what carrier requirements have the potential to influence their selection and adoption of a TMS. Second, the technical descriptors in relation to the literature and development target will be examined. This will indicate how the carrier requirements can be addressed by the TMS providers.

5.1 Customer Requirements

This section will discuss the customer requirements and their prioritization in relation to the literature.

5.1.1 Administrative Requirements

Invoice Management was ranked as the highest priority customer requirement with a score of 1,8. This is associated with the inclusion of service elements and the digitalization of services that encourages changes in service quality [55]. This implies that the service element of managing invoices is regarded as highly appreciated by carriers. Moreover, in a road freight transportation context, enhanced service quality and customer satisfaction can lead to economic benefits [54]. Connecting this to the literature on the carrier industry, it is prevalent to endure extended processes to receive a quote due to outdated IT systems [6]. However, little about the issue of *Invoice Management* appeared in the literature that suggests the ranking being this high. This discovery was unexpected and indicates that carriers are aware of the issue that and want to improve in this area. As Section 4.4.1 mentions, *Invoice Management* has a strong relationship with Data and Analytics, which can result in reduced payment delays and an improved billing process. Interestingly, it can be associated with the literature on SaaS, where the TMS service can be tailored to the carrier's need in order to pay the service provider correctly [37]. This suggests that *Invoice Management* can be related to freight forwarders as well, which can provide them value.

Order Management was ranked as the second highest priority customer requirement with a score of 1,6. The observed correlation between *Order Management* and its high score could be explained by the transport coordinator's response, see Section 4.1, that scheduling, entry, and tracking of orders helps them to monitor order statuses, shipment locations, and delivery timelines. Further, it was also stated that these functions can improve efficiency and reduce costs by minimizing errors and automating processes. These results are consistent with what previous studies have shown, that insufficient adoption of automation and digitization in crucial operations like order management has worsened the industry's already high expenses [6], and thus justifies its high ranking. As mentioned in the literature review, one of the three objectives of managing transport operations is to optimize efficiency [51]. This suggests that a strong relationship between this statement and the observed correlation has been found, supporting its statement. Furthermore, it is likely that a TMS without Order Management becomes troublesome in large volumes, in particular since the total volume of goods transported in Europe amounted to 1764 billion ton-kilometer in 2019 [5]. Therefore, this result might be a consequence of the limitations of this thesis, where medium to large-sized carriers were of relevance.

Data and Analytics Management was ranked as the third highest priority customer requirement with a score of 1,4. This correlation has been reported in the literature, where companies that possess the ability to accomplish analyzing data effectively and leverage their business advantages will gain an edge over their competitors [29]. This suggests that carriers are aware of the potential benefits that Data and Analytics Management provides, and want to take advantage of it. As mentioned in Section 4.1, the interviews concluded that the ability to examine data regarding shipment details, costs, and performance enables the identification of areas requiring improvement, specifically targeting inefficiencies, delays, and bottlenecks. These factors may explain the strong correlation between Data and Analytics Management and it is the third highest priority customer requirement.

Similarly, *Digital Freight Documents* is a customer requirement that received a priority score of 0,9. Hardly any literature exists on the issue of *Digital Freight Documents* as a TMS feature. However, traditional paper-based processes have frequently led to the loss of vital information [6]. This would suggest digitalizing documents would be beneficial for carriers to not lose vital information. Surprisingly, the priority score of *Digital Freight Documents* shows that carriers do not want to prioritize this feature. This might be a result of the amount of value this feature brings. This feature does not have a significant impact on the carriers' operation regarding effectiveness or efficiency, which might be a reason for its low priority score.

5.1.2 Electric Requirements

The customer requirement *Charging* received a priority score of 1,1. This finding was unexpected and indicates that carriers are acknowledging the potential of using and managing electric vehicles. This is also shown by a forwarder that witnessed an increase in the volume of green loads, including electric [21]. Another customer requirement connected to electric trucks is *Battery Lifespan Management*, which received a priority score of 0,9. The result revealed that skepticism exists regarding the viability of electric trucks, where it is necessary to have an effective and dependable charging infrastructure, as well as battery management. *Charging*, in combination with *Battery Lifespan Management*, would be beneficial for carriers that have electric trucks and therefore reduce the level of skepticism.

5.1.3 Optimizable Requirements

Fuel Cost Optimization is a customer requirement that also received a priority score of 1,2. The literature review found little to no data on the relationship between *Fuel Cost Optimization* and its importance. Nevertheless, fuel cost is mentioned as one of the main problems that cause transportation costs to rise, and solutions are actively searched for [26]. Therefore, it can be considered a challenge to solve this issue. In spite of this, carriers are noticing the value that this functionality brings. The result also showed that *Route Planning* is a factor concerning *Fuel Cost Optimization*, which reinforces previous research findings in the field, where the primary aim of innovations in freight transport is to achieve an improvement in service quality for customers, while simultaneously reducing the costs involved in delivering these services [55]. This suggests that *Fuel Cost Optimization* would, in combination with other features, be more beneficial for carriers than only implementing that feature.

The two customer requirements *Goods Distribution in Equipage* and *Volume and Weight Management* both received a priority score of 1,1. As Section 4.1 mentions, these customer requirements ensure smooth and efficient operations for carriers by avoiding overloading or under-utilizing vehicles. This correlates with two main objectives of managing transport objectives, namely optimizing efficiency and ensuring effectiveness [51]. Further, another important finding was compliance with regulations, where non-compliance can cause safety hazards for drivers and other road users. Previous findings in this field mention that safety is a main factor in determining the quality of transport services and the competitiveness of carriers [50]. This implies that these requirements serve multiple purposes, and can therefore provide different kinds of value for carriers.

Resource Optimization is a customer requirement that received a score of 1,1. Previous literature in this field states that ensuring efficient management of resources is important for achieving profitability [17]. This correlates with that decisions regarding transportation can have an effect on overall profitability [28]. Thus, *Resource Optimization* has a relationship with profitability and leads to it having a significant effect on carriers' business. Surprisingly, despite this relationship, *Resource Optimization* is not ranked that high in comparison to other customer requirements. However, this can be explained by the findings in Section 4.1, where transport coordinators are believed to manage their resources more effectively than any software. Therefore, the ranking is considered low because of trust. Similarly, the customer requirement *Vehicle Configuration Optimization* received a score of 0,9, and the findings also reveal a lack of trust in this feature. Previous research in this field has underlined the carriers' insufficient implementation of IT systems that handles critical operations [6]. Thus, the lack of trust in both *Resource Optimization* and *Vehicle Configuration Optimization* might be due to that advanced technology is not prevalent in this sector yet.

5.1.4 Executional Requirements

Deviation Management was ranked as the fourth highest priority customer requirement with a score of 1,3. This result is consistent with other research that has found that TMS technology can be considered crucial because of its impact on uncertainty and fluctuations within transportation networks assessment to better manage logistics [28]. Further, it can be assumed that TMS technology, in this context, relates to the management of deviations. This statement is further connected to punctuality within transportation, which has a correlation with *Deviation Management*. As mentioned in Section 4.1, the interviewees stated that traffic bottlenecks and transportation-related concerns might result in late delivery, affecting the entire supply chain. This correlates with findings that showed that punctuality is a crucial factor in determining the quality of transport services and the competitiveness of carriers [50]. This implies that the service quality and competitiveness of carriers can be improved by managing deviations, thereby providing value.

Route Planning is a customer requirement that received a priority score of 1,3. This finding was unexpected as previous research has demonstrated the importance of planning routes. In 2004, Verwijmeren mentioned that transport planning was a basic function of a TMS [25]. Furthermore, optimizing routes is mentioned when discussing new features of a TMS that would increase efficiency and productivity [27]. This particular result must therefore be interpreted with caution because it can be assumed to have a strong correlation with transport duration, which carriers ensure to meet a main objective in managing transport, namely ensuring effectiveness [51][52]. Further, the importance of *Route Planning* in this thesis can be connected to it being a standard function in the transportation industry.

Interestingly, the customer requirement *Real-time Updates for Drivers* got a priority score of 1,2. Previous research found that new technologies in the road freight transportation system facilitate real-time monitoring of traffic, as well as the detection, communication, and transmission of information [31]. This, in combination with the result, implies that *Real-time Updates for Drivers* is achievable, and is considered to be valuable for carriers. In addition, Section 4.1 revealed that task prioritization can be optimized and time can be allocated more efficiently, and since the evaluation of service quality attributes often revolves around the time saved during transportation [50], it can be assumed to be a factor that can enhance carriers' service quality.

Driver Allocation is a customer requirement that is among the lowest priority with a score of 0,9. The literature review found little to no data on the relationship between *Driver Allocation* and its low priority. However, it was stated that TMS features, namely selecting drivers with appropriate skills among others, can have a positive effect on efficiency and productivity [27]. The disparities between the literature review's statement and low priority score can be partly explained by the findings from the interviews. Here, the interviewees mentioned that the reliance on human decision-making regarding allocating drivers was a common theme across all carrier companies. Thus, there is a lack of trust in this feature. Interestingly, the advantage of SaaS is that it can be tailored to meet diverse and complex requirements of software customers [40]. This suggests that *Driver Allocation* might be possible to accomplish as a feature, but is demonstrably not a priority according to carriers.

Lastly, *Automatic Driver Allocation* is a customer requirement with the lowest priority score of 0,8. The literature review concluded that the road freight transportation market is characterized by automation [22]. Similarly, TMS is progressively automating tasks with the objective of leveraging available resources to work more intelligently [28]. Interestingly, there is a difference between the priority score and the literature review. Thus, it is difficult to justify this particular result. However, the result concluded challenges with this feature, such as assigning drivers when there are deviations on a regular basis. This might suggest that *Automatic Driver Allocation* has an indispensable relationship with *Deviations Management*.

5.2 Linking Relationship Matrix with Development Target

This section will discuss the technical descriptors in relation to literature, customer requirements and development target based on the HoQ.

5.2.1 Administrative Technical Descriptors

Geographical Information System and *e-CMR* got the lowest relative scores, by a substantial margin, with *Geographical Information System* getting 14 and *e-CMR* getting 19. The low scores for both descriptors are not surprising. The literature describes the carrier industry as having an insufficient implementation of automation and digitization [6]. Both *e-CMR* and *Geographical Information System* are digital ways of handling carrier operations. A carrier can either use paper-based CMR and human transport coordinators for route planning or *e-CMR* and a fast system that can optimize routes better than humans. By giving the two technical descriptors low scores, carriers solidify what Riedl et. al. say in their article [6]: by not utilizing technology carriers sacrifice efficiency. Based on the results from the form and interviews in this report, carriers' unwillingness to embrace technology is not surprising and the low score for the two technically inclined descriptors is not an exception. What is surprising, on the other hand, is that *e-CMR* got a higher score than *Geographical Information System*. Based on the interviews with the QFD team, *Geographical Information System* was an important part of the future of TMS.

The developers and creators of the future of the software transport system might have a different perspective than the carriers with a more daily operational mindset. The relationship matrix does, however, contain a possible answer to the higher score of *e-CMR*. *e-CMR* have more relationships with the customer requirements than *Geographical Information System*, which might be a reason for its higher score. *Geographical Information System*, on the other hand, has a strong relationship with *Route Planning* which has a higher customer requirement priority score. Therefore, one could argue that *Geographical Information System* has an importance that is more concentrated on one area - route planning. Another aspect that might have contributed to the low relative value of *Geographical Information System* is that the technology, according to the interviews, is more important for electric trucks than for fossil fuel trucks. The reason, according to the interviews with the carriers and the QFD team, is that the charging aspect of electric transports makes route planning more complex, making *Geographical Information System* a more important technology. As seen in the result, the carriers are not currently embracing electric technology (mostly due to the short-range capacity) and have no experience in this arena. Combined with the industry's low confidence in technology [6], it might be the explanation for the low value of *Geographical Information System*. Section 4.6 mentions that *Geographical Information System* received a score of 5 in the development target. By combining the development target and the fact that it is the technical descriptor with the lowest relative value, it can be concluded that this should be not be focused on first by the TMS providers.

Regulation Management got a relative value of 50 which places it around the average relative value for the technical descriptors. This result confirms previous literature within the research area. Since safety is a main factor in regards to the quality of the transport service [50], this is an expected result. *Regulation Management* had several strong relationships: *Volume and Weight Management*, *Vehicle Configuration Optimization*, *Driver Allocation* and *Real-time Update for Drivers*. The two first mentioned customer requirement is of importance, since, as mentioned in Section 4.4.1, there are restrictions in regard to what and how much goods is allowed in a specific equipage. Also, there are restrictions to the equipage setup that needs to be taken into account, as mentioned in Section 4.4.1. The two other requirements are more toward the driver where there are rules to adhere to. In addition, carriers need to adhere to regulations in order to run their operations, which emphasizes the importance of this being in place.

Business Intelligence System was the third highest ranked technical descriptor with a relative score of 60. Since *Business Intelligence System* is important for processing data and presenting it in a relevant way it had relationships with more than half of the customer requirements, with *Invoice Management*, *Data and Analytics Management* and *Fuel Cost Optimization* being strong relationships. This is in line with Ahuja's statements regarding how new TMS features can lead to increased efficiency and productivity by generating optimized transportation plans, schedules, and routes, as well as help in selecting drivers with the appropriate skills [27]. Moreover, the results show that carriers find analyses and different types of data reporting increasingly important which makes the high relative score of *Business Intelligence System* reasonable. Moreover, as mentioned in Section 4.6, *Business Intelligence System* received a 5 in the development target. This demonstrates that resources should be allocated to this technical descriptor. This result can originate from the fact that *Business Intelligence System* can analyze the carriers' operation with regard to efficiency and effectiveness.

5.2.2 Static and Dynamic Technical Descriptors

Static Hardware Properties got the second highest relative score of 72. The result showed that in order to fulfill the customer requirements it is important to know the properties of the hardware that the carriers operate. The hardware - trucks, trailers, and other hardware - is a prerequisite for transporting goods and the properties were found to have strong relationships with the following customer requirements: *Route Planning*, *Charging*, *Battery Lifespan Management*, *Vehicle Configuration Management*, *Resource Optimization* and *Fuel Cost Optimization*. As can be seen by the customer requirements, *Static Hardware Properties* are important for optimizing the utility of the hardware and thereby the operations. Since efficient management of resources is crucial for achieving profitability in the transport industry [17], maximizing the utility of the operational hardware is essential. Additionally, as mentioned in Section 4.6, *Static Hardware Properties* received a 3 in the development target. This indicates that resources should be allocated to this technical descriptor due to its relatively low depth needed regarding development.

Load Capacity, *Cargo Property*, *Tachograph Data* and *Billing and Payment Data* are all technical descriptors that are necessary for the operations of transport carriers. Technology can minimize the repetitive procedures [20] and provide storage of data such as the load capacity of resources or the property of the goods of an order. The four mentioned descriptors are of different character, but are all necessary which makes their respective relative values of between 39 to 48 unsurprising. As mentioned in Section 4.6, *Load Capacity* received a score of 3 in the development target. Further, *Cargo Property* got a score of 2, and *Tachograph Data* obtained a score of 3. Lastly, *Billing and Payment Data* received a score of 3. Due to the similarity in characteristics of *Load Capacity* and *Cargo Property*, the TMS provider can group these into the same development phase and allocate their resources among them. However, *Billing and Payment Data* should be prioritized to be able to properly handle payments. *Tachograph Data* should be focused on last in comparison to the others mentioned above in this section due to its low relative score and degree of needed proficiency.

Fleet Management Data got the relative value of 52 which is, to a certain degree, an expected result. The value shows that while the descriptor is needed in some areas, it is not essential, but rather a good to have. This is expected because it is in accordance with the carrier industry: technology is, except an order handling system, a good to have, rather than a need to have. Ensuring efficient resource management is crucial for achieving profitability [17]. According to the result, as shown in Section 4.1.3, carriers believe that transport coordinators can manage the resources with higher efficiency than any software program. Considering this, an explanation for the value could lie in the number of relationships with customer requirements. *Fleet Management Data* has relationships with six requirements, of which five are strong relationships. Even though the relationships might be strong, the customer priority score of the mentioned requirements is the lowest, with the lowest being 0.8. Section 4.6 mentions that *Fleet Management Data* received a score of 3 in the development target. In general, this suggests that TMS providers need to allocate resources to develop this technical descriptor at a later stage.

Telematics Data got a relative score of 48. This score is expected since the results of this study support previous research findings. Previous research has demonstrated the importance of new technology that facilitates real-time monitoring [31], which telematics can enable. Looking at the customer requirement that the descriptor has relationships with, there is only one requirement that regards the the transport operations during the execution phase: *Real-time Update for Drivers*. As seen in Section 4.1.4, the interviewees considered real time monitoring and tracking of deliveries important, since it allows carrier to respond to deviation in a timely fashion. Another finding, that has not been able to be found in literature, is that telematics data plays an important role in the charging and management of battery lifespan 4.3.2. This could be because of the fact that electrically powered long haul trucks are new and that little research has been done in the subject area.

5.2.3 Executional Technical Descriptors

Dispatch System was the technical descriptor with the highest relative value of 90. This means that the descriptor has the strongest relationship with all of the customer requirements in total and that the case company should prioritize its resources accordingly. The term *Dispatch System* is in this report defined as a system that enables two-way communication between drivers and transport coordinators. This is a broad definition that entails many types of information and features, but by only looking at information sharing and communication between drivers and transport coordinators through a TMS, regardless of type, there may lie an opportunity for technology developers, such as the case company. The advancement of information and communication technology has created a platform for companies to create, produce, and offer services that customers may consider superior [36]. The result of this thesis supports the claim that information and communication are important for transport carriers and that emphasis should be put on this technology when creating a TMS. According to Verwijmeren the following functions are considered fundamental in a TMS: (1) transport booking; (2) transport planning; and (3) transport monitoring [25]. This follows the traditional way of operating transport flows: booking, planning, and lastly delivery confirmation which leaves no room for managing deviations and changes through communication and information technology. Sumalee and Ho claim that new technologies that enable the detection, communication, and transmission of information are indispensable in the road freight transportation system [31]. Communication and information should therefore be as fundamental as planning since the results in this report show how unpredictable the operations of road freight transport are and that execution is just as important as planning.

The traditional way of carrier operations puts most emphasis on the planning stages of transport [25], but the emergence of new technology within information and communication gives carriers the opportunity to be more flexible in the execution phase. The result of this report solidifies the need and wish of carriers to have better two-way communication and information sharing between drivers and transport carriers. The results show that there is a gap in information sharing and communication during the operations and execution phase, which is the main reason for *Dispatch System's* high score. *Dispatch System* had multiple strong relationships with high ranked Customer Requirements: *Route Planning*, *Order Management*, *Driver Allocation*, *Deviation Management*, *Resource Optimization*, *Real-time Updates for Drivers* and *Digital Freight Documents*. In accordance with Verwijmeren´s fundamentals for a TMS, *Route Planning*, *Order Management*, *Driver Allocation*, *Deviation Management* and *Resource Optimization* all have strong relationships with *Dispatch System* [25]. Therefore, it is an expected result that *Dispatch System* would get a high relative value. However, it was not expected that it would get the highest relative value, considering the analog nature of the carrier industry. One potential reason for its high value can be that carriers are starting to realize the benefits of technology and information sharing within their operations. Additionally, as mentioned in Section 4.6, *Dispatch System* received a 5 in the development target. This points to that this technical descriptor needs to be fully developed in order to satisfy the stakeholders, which in this case are carriers. This result seems possible due to that it has the highest relative value, which indicates that TMS providers need to focus their resources on this technical descriptor.

Scheduling Tool for Drivers got a relative score of 57, almost as high as *Business Intelligence System*. Since planning is a big part of the operations of carrier transports [25], the high relative score of *Scheduling Tool for Drivers* is no surprise. Planning of resources, such as drivers, is a way of optimizing the logistics operation [27], which is important for carriers. Another aspect that might be the reason for the high relative score is the way effective planning can help carriers to select the right drivers for the appropriate tasks, based on skills [27]. Furthermore, as mentioned in Section 4.6, *Scheduling Tool for Drivers* received a 3 in the development target. This shows that resources from the TMS provider should be allocated to this technical descriptor. The reason is that it has a relatively low degree of satisfaction while being the fourth highest ranked technical descriptor in terms of relative value.

Order Analysis got a relative value of 55, which is surprisingly low, considering the fact that the management of orders is the fundamental function of a TMS. Without it, a TMS would not have much use [25]. *Order Analysis* does not, however, cover the function of displaying orders, but rather the management and optimization aspect of managing orders. Therefore, this result shows that carriers do not necessarily need the function where the TMS gives the transport coordinator ways of optimizing and analyzing the orders. This is in line with the standard of the carrier industry where the carriers prefer to have humans doing the thinking rather than a TMS. According to all of the carriers that have been interviewed, the TMS does not need to help the transport carriers with the planning. More emphasis was on the reporting side of data and order management rather than the planning side, which might be a reason for the value of 50 for *Order Analysis*. Further, as mentioned in Section 4.6, *Order Analysis* received a 4 in the development target. This indicates that resources from the TMS provider should not be allocated at the start of the development to this technical descriptor. This is a result of it must having a high degree of proficiency to please the stakeholders, while not having a high relative score compared to other technical descriptors.

6 Conclusion

The purpose of this thesis was to use a QFD approach to examine the interaction between carrier requirements and TMS providers in order to understand how TMS providers can address the needs of carriers, which were also identified. First, 16 customer requirements were collected through a thematic analysis of data collected from semi-structured interviews with medium to large-sized carriers in Scandinavia and an online questionnaire. Next, the customer requirements were prioritized through an online questionnaire. Thereafter, 14 technical descriptors were collected through semi-structured with the case company and analyzed using thematic analysis. Subsequently, the relationship between customer requirements and technical descriptors was analyzed by the QFD team. Lastly, the correlation between technical descriptors and their development target was determined by interviews with the case company. Moreover, a literature review on road freight transport and service development was formulated. Section 6.1 will explain the contributions to theory and literature. Further, Section 6.2 will elaborate on the result of this thesis regarding practitioners. Lastly, Section 6.3 will state further research within this subject.

6.1 Theoretical Implications

By analyzing the carrier requirements and their prioritization, this thesis highlights the requirements that have the potential to influence the selection and adoption of a TMS. The customer requirement that received the highest priority score was *Invoice Management*. This was not expected and might suggest that carriers are focusing more on service quality. Further, *Order Management* was ranked as the second highest priority customer requirement because of its potential to bring advancements in terms of automation to improve efficiency. This might suggest that the carrier industry is facing technological advancements that possibly will have a positive impact on their operations. The customer requirement that received the third highest priority score was *Data and Analytics Management*. This is a result of carriers noticing the potential to effectively analyze data and exploit its benefits, thereby gaining an edge over their competitors. This might suggest that carriers are becoming more keen on using data for their operations. To conclude, the three highest priority carrier requirements are administrative requirements and have the most potential to influence the selection and adoption of a TMS. Nevertheless, the remainder of the carrier requirements will also be listed in descending order of their prioritization since they also can potentially shape the selection and adoption of a TMS: *Deviation Management*, *Route Planning*, *Real-time Updates for Drivers*, *Fuel Cost Optimization*, *Goods Distribution in Equipage*, *Volume and Weight Management*, *Charging*, *Battery Lifespan Management*, *Resource Optimization*, *Vehicle Configuration Optimization*, *Driver Allocation*, *Digital Freight Documents*, and *Automatic Driver Allocation*. To conclude, all elicited requirements indicate that there are many important factors to take into consideration in the carriers' operation. Currently, most of these requirements for a TMS are done by a human. Throughout this study, it is shown that the carrier industry is undergoing a technological shift, thereby making it more advanced than before.

By analyzing the technical descriptors in relation to carrier requirements and development targets, this thesis highlights how TMS providers can address the requirements. The technical descriptor that received the highest relative value is *Dispatch System*. This suggests that a TMS provider can fill a gap in the market by providing carriers with means to better two-way communication. *Dispatch System* was strongly linked to, among other requirements, *Order Management*, *Driver Allocation*, *Resource Optimization* and *Real-time Update for Drivers*. These are all important during the execution phase and solidify the need for real-time monitoring in carriers' operations. *Static Hardware Properties* got the second highest relative score which is a prerequisite for any type of resource optimization. Although important, the degree to which the descriptor needs to be developed is relatively low. This means that the development depth is relatively low while bringing substantial value to the TMS. In terms of customer requirements, the descriptor is relevant for all of the optimization requirements, as well as the requirements for electric transports. *Business Intelligence System* got the third highest relative score, solidifying carriers' inclination to start basing decisions on analyses. In order for the descriptor to be usable in the intended context, it should be developed to its fullest extent. The technical descriptor was highly relevant for the following customer requirements: *Invoice Management*, *Data and Analytics Management*, and *Fuel Cost Optimization*. The technical descriptor that got the lowest value is *Geographical Information System*. Even though this might indicate that it is a less important descriptor, the development score was determined to be the highest possible. It also has a strong relationship with the customer requirement *Route Planning* that has the fourth highest requirement score. Despite it having the lowest relative value, *Geographical Information System* is important if the TMS provider focuses on route planning. To conclude, all technical descriptors indicate how advanced the TMS needs to be in order to successfully meet the carriers' requirements.

6.2 Implications for Practitioners

The road freight carrier industry is not known for the adoption of technology, but rather the opposite. The results from this research show what TMS providers should focus on in order to cater to the needs of carriers. In this study, both customer requirements and technical descriptors have been discussed. For TMS providers, both types are relevant.

In regard to customer requirements, the most important features are connected to administrative tasks. It is important for TMS providers to offer carriers the basic functionality for managing transports in two ways: First, the system needs to be able to manage orders. Second, it needs to be able to manage invoices. Furthermore, it was found that the carriers found data and analytics important, which might indicate a newfound and growing inclination for carriers to adopt analytics through technology. The executional and optimizable requirements got similar values, which confirms the industry's dependency on human brainpower rather than using software. For TMS providers, this is an area where development should be focused. The prioritization of these requirements is lower than that of the administrative requirements, but the executional and optimizable requirements are where a software provider can stand out from other TMS providers. Last of all requirements came the electric requirements, which solidifies carriers' somewhat doubtful attitude toward electric long-haul trucking. While this is a way for TMS providers to stand out, it implies a higher risk than the focus on the other customer requirements, since the customer need is still low.

In order for TMS providers to fulfill the customer requirements they need to implement some technical descriptors. The most important technical descriptor that every TMS provider should focus on is *Dispatch System*. It was found that communication and information sharing between the transport coordinators and drivers is important for carriers. Furthermore, it was found that business intelligence and static hardware properties are two technical descriptors that are important in order to fulfill the customers' requirements. The technical descriptor that got the highest relative value is Dispatch System. By focusing on developing the system to the fullest extent and becoming market-leading in the technology, a TMS provider can fill a gap in the market by providing carriers with means to better two-way communication. Dispatch System was strongly linked to, among other requirements, Order Management, Driver Allocation, Resource Optimization, and Real-time Update for Drivers. These are all important during the execution phase and solidify the need for real-time monitoring in carriers' operations. Lastly, the geographical information system, which got the lowest score, should not be discarded, since the descriptor only is relevant for route planning. Route planning, however, got one of the highest values as a customer requirement, which, for a TMS provider, means that route planning is an interesting area of development, that carriers find important.

6.3 Limitations and Future Research

This thesis focused on utilizing a QFD approach to analyze the interplay between carrier requirements and TMS providers, enabling a comprehensive understanding of how TMS providers can effectively cater to the needs of carriers. This was done on medium to large-sized carriers in the geographical scope of Scandinavia, but it would be interesting to do a similar study with a different geographical scope to see if the carrier needs changes depending on location.

Additionally, conducting a case study at a TMS provider would be of great interest to ascertain if the outcomes align with the aforementioned requirements and technical descriptors. Moreover, it would shed light on the varying perspectives of different TMS providers regarding technical descriptors, considering the multitude of possible approaches to address the same problem.

Furthermore, it would be interesting to make a quantitative study on this topic to confirm this result or to elicit new customer requirements. This would be a more extensive study with more participants, enabling the possibility of using Fuzzy QFD to avoid uncertainties or imprecisions.

Lastly, an interesting topic for future research would be a continuation of the most important requirement or technical descriptor found in this study, namely invoice management or dispatch system. Here, the researchers can try to measure the exact impact of having this function or system, allowing for a more in-depth study.

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A

Appendix: Customer Interview

1. Can you describe your role within the company?
2. How many drivers do you have per truck?
3. More specifically, what does a transport dispatcher do at the company?
4. What system(s) do you use and for what purpose?
5. Would you prefer using one rather than many systems?
6. How often do you use the system(s)?
7. What do you want from the system(s) that are not currently supported? How would it affect your daily work?
8. Do you drive electrical trucks?
9. What do you need in order to drive electric trucks?
10. What is your view of the carrier industry in 10 years?
11. What is your view of the system that a transport dispatcher will use in 10 years?

B

Appendix: Questionnaire

1. What is your role in the carrier company you work for?
2. What kind of system do you use to manage orders?
3. Prioritize the following requirements according to “Don’t need”, “Good to have” or “Must have”:
   (a) Route Planning
   (b) Charging
   (c) Battery Lifespan Management
   (d) Goods Distribution in Equipage
   (e) Volume and Weight Management
   (f) Vehicle Configuration Optimization
   (g) Order Management
   (h) Invoice Management
   (i) Driver Allocation
   (j) Automatic Driver Allocation
   (k) Deviation Management
   (l) Data and Analytics Management
   (m) Resource Optimization
   (n) Real-time Update for Drivers
   (o) Digital Freight Documents
   (p) Fuel Cost Optimization
4. If a system could help with transportation planning, what would you want it to do? (Disregard technological limitations; assume that anything is possible.)
5. In your opinion, can electric trucks be coordinated in the same way as conventional (diesel) trucks?
6. Why do you think that electric trucks can/not be coordinated in the same way as conventional trucks?
7. Do you think a system can solve the tasks that a transport dispatcher does today without the help of a human?
8. Why do you think a system can/can’t manage to replace a transport dispatcher today?

C

Appendix: Case Company Interview

1. Could you provide a brief overview of your role within the company?
2. From your perspective and role, what are the key factors/attributes of the TMS service(s) offered by the company?
3. Which TMS service(s) do you believe brings the most value to the customers?
4. What does the customer service experience entail connected to the TMS service(s), and does it vary based on the customer?
5. Have there been any notable customer complaints about the TMS service(s) offered?
6. What alternatives were you discussing before implementing the current solution for the TMS?
7. In your opinion, why does the company have a limited presence and customer base for your TMS in Scandinavia?
8. Do customers have any specific sustainability requirements or preferences?

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