Digitalization's Effects on Transport Planning and Specifically the Transport Coordinator's Role

Sandra Lechtenberg(✉) and Bernd Hellingrath

WWU Münster, Münster, Germany
{sandra.lechtenberg,bernd.hellingrath}@wi.uni-muenster.de

Abstract. Road freight transport has become a vital part of today's life, and its importance will only rise in the future due to developments such as increasing e-commerce orders. Transport planning has become more complex and has to deal with many difficulties such as demand volatility, high customer expectations, or the consideration of legal regulations. The fast-changing environment makes dynamic and highly reactive planning, typically done by the transport coordinator, necessary. Incorporating technology is a promising way to deal with the complexity and dynamic environment of transport planning. Indeed, more data and computing power is available than ever before, and developments coined under "digitalization" are transforming transport planning. Before understanding the benefits digitalization can have, examining its influences on the industry, the roles participating in transport planning, and their relationship is necessary. Hence, this paper establishes an overview of roles associated with transport planning, identifies digitalization's effects on transport planning and specifically the transport coordinator, and then provides an updated overview of roles considering these effects. The results show that new relations and roles are important for transport planning. The role of the transport coordinator itself is transformed mainly due to the emergence of platform-based business models.

1 Introduction

The importance of freight transport, i.e., the movement of goods from a starting area to a destination area, is ever increasing. In 2017, more than 1.9 billion tonne-kilometers were reached only within the EU. More than 70% can be attributed to road freight transport, making it the most used transport mode for inland transport (eurostat 2018). While the transport volume, in general, is continuously growing due to, e.g., globalization and increasing e-commerce orders, especially the share of less-than-truckload road transport, i.e., the transportation of goods, which do not fill a complete truck, is rising (Ridouane et al. 2020). Moreover, road transport is and most likely will be favored over other transport means due to the demand for fast and flexible delivery as well as direct access to customers. Compared to other transport modes, road transport exhibits some characteristic features that influence all activities of the industry. Routing is more flexible due to a ramified road infrastructure, less than truckload deliveries are very common, a wide range of products are suitable for road transport and lead as well as delivery times are

U. Buscher et al. (Eds.): *Logistics Management*, LNLO, pp. 33–48, 2021.
https://doi.org/10.1007/978-3-030-85843-8_3

typically shorter than for other transport modes (Günther and Seiler 2009; Ivanov et al. 2017). The whole road freight transport industry faces numerous challenges. Prevailing business conditions like demand volatility, high customer expectations with regard to delivery speed, and shorter product life cycles require changes in transport planning and management. Additionally, the industry has to deal with numerous legal regulations regarding environmental aspects, working hours, or data protection, as well as internal challenges such as rising transport costs, driver shortage, or cumbersome business processes (Günther and Seiler 2009; Holcomb et al. 2014; Ji-Hyland and Allen 2020; Liachovičius and Skrickij 2020).

All of the mentioned challenges and influences need to be considered in particular when planning road freight transports. Usually, planning is done by a central role, the transport coordinator, responsible for creating transport plans and coordinating transports. A transport plan sets the ground for a successful transport execution, and the transport coordinator needs to pay attention to given circumstances such as regulations, infrastructure, or available resources. Moreover, planning has to be done under high time pressure (Seiler 2012). Due to more aggressive service promises and a highly competitive environment, there is an increasing freight demand, including high day-to-day freight volume fluctuations, which puts pressure on the transport coordinator's operational planning (Ridouane et al. 2020). Every day, a huge number of transport orders have to be processed, routes to be planned, and drivers to be assigned to trucks as well as trucks to routes. In addition, external influences, such as the current traffic situation or weather, and uncertainty, such as sudden changes in the traffic situation due to accidents, can change the setting and lead to the need to update a transport plan in real-time. Hence, there is a need for transport coordinators to improve their operational and real-time planning capabilities to consider all influences (Ridouane et al. 2020; Sigakova et al. 2015; Stank and Goldsby 2000).

One promising possibility to do so is the use of new and emerging technology. Incorporating technology has always been used to improve planning processes regarding visibility, speed, and dependability (Belvedere and Grando 2017). However, recently, new technological innovations are developed and made available to the industry faster. Technological innovations change how business is done or create entirely new business models. Their use is subsumed under the term "digitalization", which seems to be a valuable opportunity for transport coordinators. The *27th Annual Study of Logistics and Transportation Trends* shows that the vast majority of respondents agreed with the statement: "Being a digital business is important to the success of my company" (Schaefer et al. 2018). There is an increasing availability of computing power and data, e.g., via GPS or sensor data, in the road freight transport industry. Therefore, transport coordinators could make use of these resources and apply new technologies such as artificial intelligence to create efficient transport plans considering all relevant influences and, in general, improve their operational and real-time transport planning (Barua et al. 2020; Ridouane et al. 2020; Schaefer et al. 2018).

Overall, the digitalization of road freight transport changes processes and allows for new business models. Therefore, it also influences the transport coordinator's interactions during transport planning. To reap the promised benefits of using new technologies, it first must get clear where and how the transport coordinator can apply them. There is

currently a lack of understanding of emerging technology's influences on the industry, in general, and on the central role of the transport coordinator and its task of transport planning specifically (Barua et al. 2020; Belvedere and Grando 2017; Liachovičius and Skrickij 2020; Pernestål et al. 2021).

This paper wants to provide a first step towards addressing this lack of understanding. It examines the influences digitalization has on the transport coordinator's role and its relationship to other industry roles, specifically when creating transport plans that are the basis for the actual transport execution. The following three research questions (RQ) are addressed:

1. What are typical roles in the road freight transport industry relevant for operational and real-time transport planning, and what is their relation to the transport coordinator?
2. Which effects does digitalization have on operational and real-time road freight transport planning?
3. How do digitalization's effects on operational and real-time road freight transport planning change the transport coordinator role and its relationships to other roles?

The following section synthesizes existing literature to answer RQ1 and creates a framework picturing roles in road freight transport and their relation to the transport coordinator. Then, the methodology to answer RQ2 and 3 – based on the results of RQ1 – is described. The results are presented in the following two sections: First, it is examined how digitalization influences transport planning and the transport coordinator. Second, the picture of roles and their relationships is updated accordingly. The paper closes with a conclusion summarizing the main results, highlighting limitations and future research options.

2 Roles in Road Freight Transport

Freight transport aims to "bridge the distances between spatially separated places of supply and demand" (Tavasszy and Jong 2014). Goods can be transported using various means grouped into road, rail, air, inland waterways, and sea. Indeed, the choice of a suitable transport mode or problems of inter-modal transport are the most researched decision problems within transport management (Günther and Seiler 2009; Tavasszy and Jong 2014). Different roles are relevant for transporting freight via roads. The differentiation between a company and its role is essential. On the one side, a company can act as more than one role, and on the other side, one role can be fulfilled by more than one company. Consequently, there is an n:n-relationship between companies and roles.

Various authors have discussed those roles, their responsibilities and found different names and definitions for them. However, there are evident similarities, and Table 1 shows how different labels can be aligned.

As stated in the introduction, this paper focuses on the central role *Transport coordinator* and its task of transport planning. This process is based on transport orders that provide relevant information about the transport to be conducted. They are typically received from *consignors* or *consignees*, i.e., whenever something needs to be shipped

Table 1. Overview of roles' and their names in scientific literature

	Consignor	Consignee	Transport operator	Transport coordinator	Facility & infrastructure provider	Authorities
Bäumler and Kotzab (2016)	Shipper	Receiver	Transport company, driver	Traffic control center	Systems provider	Public authorities
Crainic et al. (2018)	Shipper	Customer	Carrier	Freight logistic provider	Facility & Infrastructure Manager	Institutional Authorities
Holmgren et al. (2012)	Producer, transport buyer	Customer, transport buyer	[actor on physical level]	Transport chain coordinator, transport planner	-	-
Ramstedt and Woxenius (2006)	Consignor	Consignee	Transport operator	Transport coordinator	Terminal operator, supporting actors	-
Schroeder et al. (2012)	Sender	Recipient	Carrier	Transport service provider	-	-
Seiler (2012)	Sender	Receiver	Carrier	Shipper	-	-
Wang et al. (2007)	Shipper	Customer	Carrier	Shipper or carrier (organizational unit)	Technology & financial service provider	-

from a consignor to a consignee, both can send the order to the coordinator (Crainic 2000; Seiler 2012). The transport coordinator then creates a transport plan, also referred to as an operational or load plan, that includes all relevant information about the transport such as loads, routes, departure and arrival times, or possibly (de-)consolidation points (Crainic 2000; Ramstedt and Woxenius 2006). The transport plan has to oblige to existing regulations posed by *Authorities* and included routes and time schedules have to consider infrastructure such as roads or terminals provided and managed by *Facility & Infrastructure Providers* (Bäumler and Kotzab 2016; Crainic et al. 2018; Ramstedt and Woxenius 2006). The coordinator can then decide to operate the transport itself (acting as coordinator and operator as often done by third-party logistics providers) or to hire a transport operator (as in the case of a freight forwarder contracting a carrier to conduct the transport) (Ramstedt and Woxenius 2006; Seiler 2012).

Figure 1 provides a simplified overview of the roles and their central relations. For ease of representation, the figure only displays the transport coordinator's relationships during transport planning. Relationships between roles other than the coordinator are not depicted in Fig. 1.

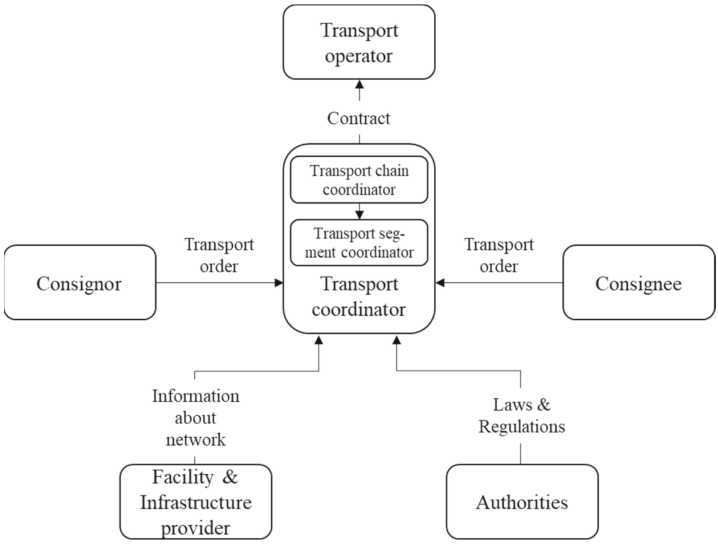

Fig. 1. Overview of roles and relationships in road freight transport from the transport coordinator's point of view

It is essential to notice that a transport coordinator typically does not process a single transport order into a single transport plan. Instead, multiple transports are planned simultaneously, using terminals for (de-) consolidation and contracting various transport operators to carry out transport segments (Crainic 2000; Ramstedt and Woxenius 2006; Schroeder et al. 2012). This makes a hierarchical division of the transport coordinator role necessary, as also proposed by Holmgren et al. (2012) and Ramstedt (2008). Companies can hire a *transport chain coordinator* and assign responsibility for their whole transport chain to them. The *transport chain coordinator* can then separate the transport chain into segments (e.g., based on regions or countries) and hire other *transport segment coordinators*. This leads to the establishment of a hierarchical relationship within the transport coordinator role. A possible scenario is, for example, that a fourth party logistics provider takes care of a global manufacturer's whole distribution network and contracts a third-party logistics provider to coordinate transports within a specific country (cf. for example, Hsiao et al. (2010) for more information on fourth and third-party logistics providers and their covered services). It has to be noticed that it is possible to have both a transport chain and segment coordinator or only one of them. The existence of roles always depends on the viewpoint of definition and the considered scenario.

Due to the increased volume to be transported and the rising customer expectations – as described in the introduction – requirements for the transport coordinator have changed during the last years. These changes re-shape the transport coordinator's role,

the relationship to other roles and may also lead to the emergence of entirely new roles. Hence, this paper aims at uncovering those changes and provide an updated overview of roles and relationships.

3 Methodology

RQ1 could already be answered in the former section by synthesizing existing literature and deriving typical roles and their relationship to the transport planner resp. coordinator. Methodology-wise, it has to be mentioned that in addition to the sources presented in Table 1 to establish the roles' overview, further publications have been used to evaluate the developed scheme. Both scientific papers and reports published by practitioners confirmed the derived roles, and hence it was safe to assume that the set of roles presented in Table 1 and Fig. 1 is complete.

To answer RQ2 and 3, i.e., to identify digitalization's effects on operational transport planning and their consequences on the transport coordinator's role, a multi-vocal literature review (MLR) has been conducted as proposed by Garousi et al. (2019). In general, literature reviews are a suitable tool to identify existing knowledge on a topic (Thomé et al. 2016). Hence, it is chosen to provide a structured overview of how digitalization affects transport planning and how far these effects are addressed in the literature. The main feature distinguishing an MLR from a structured literature review is the additional consideration of grey literature. Hence, an MLR provides a structured way to gain insights both from scientific and practice-oriented literature. Especially concerning technological trends, some consultancies and more prominent companies are well-known for conducting studies or publishing reports. These publications are a valuable source for gathering a broader picture of digitalization's effects on road freight transport (Garousi et al. 2019). While other research methods such as expert interviews or case studies might deliver more in-depth information, an MLR is suitable as a first step to examine the topic at hand and synthesize what is already known and discussed in the literature. Garousi et al. (2019) propose five phases to conduct an MLR: (1) Search process, (2) Source selection, (3) Study quality assessment, (4) Data extraction, and (5) Data synthesis.

(1) Search process: The search process was divided into (1a) searching for scientific literature, i.e., white literature, and (1b) searching for grey literature. Scopus was used as one of the largest scientific databases during phase 1a to search for "digital* AND road AND transport* AND (freight OR product* OR goods OR item OR commodit*)" in the title, abstract, and keywords. Only results published in 2017 or later were considered to ensure a very recent picture of the influence of digitalization. The search resulted in 117 hits. A similar search was then conducted in the standard Google search engine to conduct phase 1b and look for grey literature. Here, a different search term "*digitalization AND road freight transport AND filetype:pdf*" was used for two reasons: (1) restricting the filetype to PDF excluded blog entries or similar, leading to hits that were mainly white papers, studies, and reports relevant to the topic (cf. Garousi et al. (2019) for a discussion on different reliability levels of grey literature) and (2) the search term used in Scopus did mainly yield links to scientific sources. Industry uses slightly different terms to describe the same phenomena, and hence the search term was adapted accordingly. The search resulted in roughly 138.000 hits. As it is impossible to review all hits due to

time and resource constraints, Garousi et al. (2019) propose different criteria to decide when to stop the search. Our search combined the criterion of theoretical saturation with the bounded effort one. We looked at the top results until at least 20 did not provide additional insights. This has led to an examination of the first 130 results, and the search was stopped at that point. While the stopping criteria still do not entirely eliminate subjectivity, theoretical saturation is a good way to identify relevant information while keeping the effort manageable. Since search results are sorted according to relevancy, it is unlikely that there will be a hit with completely new information sorted after 20 irrelevant ones.

(2) Source selection and (3) study quality assessment: During the second and third phase, the abstract of all hits for white and the first pages of all hits for grey literature were examined to decide whether they are relevant for this paper's objectives. For white literature, 22 out of 117 hits were regarded as relevant after reviewing their abstract. After a full-text review, six additional sources were excluded, leading to a set of 16 papers for further examination. Excluded sources either focused on other transport modes, did not discuss digitalization in relation to transport planning, or examined public transport. The same exclusion criteria as before have been applied to the investigated hits of the Google search. In addition, pure advertisements or product presentations, presentation slides, and scientific sources were excluded. A first rough scan led to 13 relevant results. This number was reduced to 8 pieces of grey literature after a more in-depth look into the content and quality of each publication. So overall, the set for investigation consists of 24 publications, 16 from white and eight from grey literature, which contain relevant content and exhibit high quality. Table 2 provides an overview of the so-far-described phases.

Table 2. Overview of the search process, source selection, and quality assessment

	White literature	Grey literature
Search engine	Scopus	Google
Search term	Digital* AND road AND transport* AND (freight OR product* OR goods OR item OR commodity*)	Digitalization AND road freight transport AND filetype:pdf
Search results	117 publications	Reviewed first 130 of about 138.000 hits due to theoretical saturation
Exclusion criteria	Focus on other transport modes; examination of public transport; no discussion of digitalization concerning transport planning	
		Scientific source; advertisement or product presentation; presentation slides
Abstract review	22 remaining publications	13 remaining publications
Full-text review	16 remaining publications	8 remaining publications
Final set	24 publications	

(4) Data extraction and (5) data synthesis: Each source is reviewed during the data extraction phase, and all information relevant to answering the RQs is extracted. We

have read all publications in detail and extracted which effects of digitalization they analyzed and how they describe the impacts on road freight transport planning. The gathered insights were then put into categories to provide a data synthesis. As there is no suitable overview existing so far, the categories have been defined inductively according to Mayring (2000) based on the information extracted from the papers. Hence, the categories were built and adapted during data extraction. At the end of the category definition, each category encompasses a specific effect of digitalization and contains all relevant information provided by the identified publications. Instead of separating digital developments according to their content (e.g., autonomous driving), the categories group them according to their influence on the transport coordinator role (e.g., new data sources). Based on the categories' content, RQ3 is answered. It is examined and discussed how the impacts influence and change the transport coordinator's role and relationships to other roles.

4 Digitalization's Effects on Transport Planning

The identified scientific and grey literature was analyzed regarding their description of digitalization's effects on transport planning. Especially the number of scientific sources was lower than expected. Additionally, it became apparent that research papers typically discuss a particular issue and barely view digitalization's effects from a broader standpoint. Pernestål et al. (2021) have noticed the same and constitute an exception in that they discuss various possible effects of digitalization. Following their idea, this paper aims at considering various aspects of digitalization instead of focusing in-depth on a specific one. These effects include "for example the use of digitized data, connected vehicles, and automated driving" (Pernestål et al. 2021). Grey literature tends to go along with this view and discusses digitalization's effects from a broader perspective. The focus is often put on the emergence of new business models and how they change the industry (e.g., Baron et al. (2017) or Schönberg et al. (2020)). Despite the different levels of detail in scientific and grey literature, digitalization's effects on road freight transport planning could be extracted from all identified papers and then be summarized in categories according to their influence on transport planning. Each category is shortly described concerning which effects of digitalization they encompass and how this affects the roles in transport planning and their relation to the transport coordinator. The following section then subsumes these effects in an updated framework depicting the changing roles and relations.

4.1 New and More Data Sources

All sources agree on the fact that aspects such as increased and cheaper storage capacities as well as emerging technologies such as connected cars or increased tracking and tracing lead to the availability of more data (e.g., Federal Ministery of Transport and Digital Infrastructure (2019), Ghosh et al. (2018) or Heistermann et al. (2017)). For transport planning, this means that more and new data sources can and need to be considered when designing a transport plan. Data can either be collected internally or acquired from external data providers. Examples are movement data, weather data, or detailed

information about the road network and its status (Federal Ministery of Transport and Digital Infrastructure 2019; Ghosh et al. 2018; Schröder and Cabral 2019). Other sources even base planning on a completely digital model of the road network (Komiya et al. 2019; Korhonen et al. 2017).

In summary, using more data for transport planning can be beneficial, and it can either be collected and stored internally or acquired from external sources. Consequently, the new role of "Data provider" becomes relevant for transport planning.

4.2 New Laws and Regulations

On the one hand, digitalization allows for innovations that need to be regulated before implementation. The most famous examples with regards to road freight transport are truck platooning (Seidenova et al. 2020), autonomous driving (Engholm et al. 2020), or electric vehicles (IRU 2018; Nicolaides et al. 2019). While the technology might be (almost) ready for implementation, various legal aspects, such as liability issues, need to be clarified. On the other hand, digitalization offers new possibilities to set and monitor new regulations. Examples that literature thinks about are kilometer-based taxes (Pernestål et al. 2021) or the smart tachograph to avoid breaching driving hour regulations (Baldini et al. 2018).

Once new regulations have been established, a transport coordinator's relation to authorities is affected. New regulations need to be considered just as maximum driving hours or similar today.

4.3 New and Digital Infrastructure

Two significant influences affect the infrastructure. First, the development and increased use of electric vehicles require establishing a new charging infrastructure (Nicolaides et al. 2019). When incorporating electric freight vehicles, a transport coordinator also needs to schedule charging times and places. Information about these can be acquired from according infrastructure providers. Second, digital infrastructure and its providers become more relevant to freight transport planning, resulting in adding them as a new role. Increased data exchange is only possible via gigabit networks (Federal Ministery of Transport and Digital Infrastructure 2019). Cloud providers offer the infrastructure to analyze the data and use high processing power for complex and powerful algorithms (Baron et al. 2017).

Transport coordinators will rely on this new and digital infrastructure to process more data, analyze it faster and more in-depth to create more efficient transport plans.

4.4 New Software or Service Providers

Apart from new actors providing data or digital infrastructure, new software or service providers will also play an essential role in transport planning. Providers will offer new and advanced fleet or transport management systems to enhance transport planning (Riedl et al. 2018; Schönberg et al. 2020). Many providers are expected to provide their software as a service (SaaS) (Graser et al. 2017). Such services could encompass

advanced analytics capabilities (Schönberg et al. 2020) or blockchain-based solutions such as smart contracts (Federal Ministery of Transport and Digital Infrastructure 2019).

Transport coordinators can use the offered services to outsource specific transport planning tasks such as calculating optimal routes or performance measurement. Additionally, the provided software and services can increase the efficiency and transparency of transport planning.

4.5 Platform-Based Business Models

One of the most discussed effects of digitalization is the emergence of platform-based business models, which especially grey literature addresses. Simply said, platforms provide a basis for transport buyers and sellers to interact digitally and engage in business (Jain et al. 2020). Currently, platforms focus on the non-contracted business segment, i.e., are a digital version of the spot market. However, the related business models are expected to threaten and fundamentally change the business models of classical freight forwarders or logistics service providers (LSP) (Baron et al. 2017; Graser et al. 2017). There are different names for and manifestations of such business models: freight transport exchanges (Jain et al. 2020), digital freight forwarders (Jain et al. 2020), digital freight exchanges (Baron et al. 2017), freight exchange platform (Schönberg et al. 2020) or digital connectors (Hentschel et al. 2019). While slight differences among those are discussed, mainly revolving around whether a provider owns assets or regarding the offered services and functionalities, a clear distinction cannot be made so far (Jain et al. 2020). Hence, all platform-based business models are joined in this category.

Typically, transport coordinators act as buyers on platforms and use them to contract transport operators, who offer their free capacities (Jain et al. 2020). However, platforms may also offer matchmaking algorithms or other additional services that allow direct interaction, tendering, and contracting between transport buyer and seller. In such a case, a platform can also – at least partly – take over the role of a transport coordinator. However, so far, industry-specific characteristics impede the broader expansion of platform models and the obsolescence of traditional freight forwarders and LSPs (Hentschel et al. 2019). Nonetheless, the literature highlights the importance of platform-based business models. Primarily grey literature discusses successful examples of new market entrants, and established companies have also started to offer their own platform solutions (e.g., Schönberg et al. 2020).

In summary, two main effects on transport planning result from platform-based business models: (1) Transport coordinators can use platforms to interact with mainly transport operators, and (2) platforms and their offered functionalities can be used as a substitute for a transport coordinator.

5 Digitalization's Influence on the Transport Coordinator

Based on digitalization's effects on transport planning, which are described and categorized in the section before, it becomes clear that the overview of roles and their relationship to the transport coordinator must be updated. There are new roles like the data provider and changed relationships, such as providing more or different information

about the network (e.g., electric freight vehicle utilization). Moreover, when looking at the transport coordinator's role, platform-based business models need to be considered. Hence, Fig. 2 provides an update to the first figure and depicts the new roles and relationships of road freight transport, including all the afore-discussed digitalization effects. There are some roles and relationships that are not directly affected by digitalization and remain the same. While, e.g., the interaction between a transport coordinator and a consignee might become digital or use different IT systems, the goal of this relationship stays the same: sending transport orders. Hence, such relationships can be considered unchanged and are depicted as light grey in Fig. 2.

Two of the effects, namely *New laws & regulations* and *new infrastructure*, are only indirectly visible in the overview of Fig. 2. They do not lead to the addition of new roles or relationships, but they change the already existing connection between *Facility & Infrastructure provider* and *Transport coordinator* as well as *Authorities* and *Transport coordinator*. As elaborated before, the emergence of e-vehicles or truck platooning leads to a new infrastructure that needs to be considered when planning transports. Hence, the information about the existing network stemming from *facility and infrastructure providers* changes accordingly and incorporates new infrastructure information. Similarly, authorities will provide information about new *laws & regulations* that are passed regarding digital technologies, innovations, and alike.

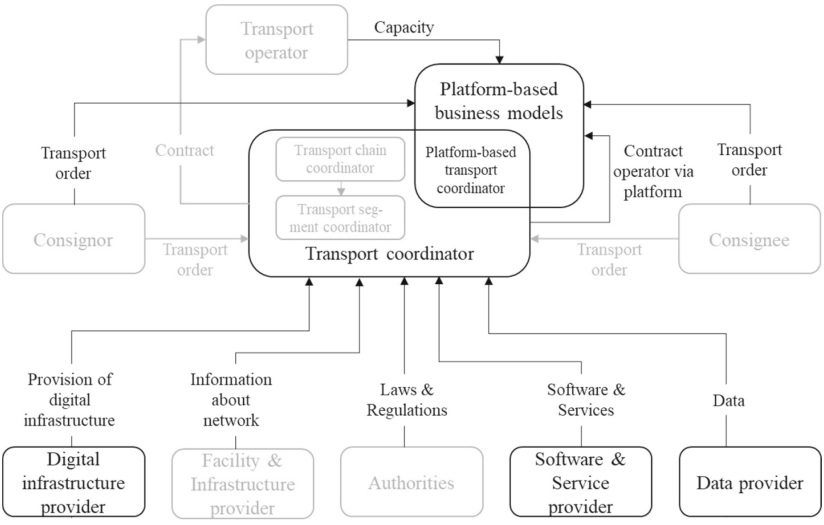

Fig. 2. Updated overview of roles and relationships in road freight transport from the transport coordinator's point of view (unchanged roles and relationships are depicted in light grey)

Apart from changing existing roles' relationships, digitalization also leads to the need to consider additional roles: *digital infrastructure provider*, *software & service provider,* and *data provider*. While transport coordinators have used software and data before, digitalization has led to a new way of using them and creates new value associated with data and resulting insights. Data is now generated and stored internally and bought from

external sources, leading to the additional data provider role. This role can be occupied both by external data providers and internal departments or similar.

Transport planning and the necessary data analysis now often require higher processing power, and while assets such as new servers can be bought, digital infrastructure such as cloud solutions or web services will often be rented and used. The new role of a *digital infrastructure provider* supplies such infrastructure. Finally, some planning process steps and data analytics tasks can be outsourced to a dedicated *software & service provider*. Such providers might offer specific software or algorithms that help prepare and process data or even take care of whole planning or analysis steps and provide this service to transport coordinators. In general, all three new roles can be affiliated to the increasing availability, significance, and value of data, which strongly influences the transport planning process. It has become necessary to incorporate more data to gain better results. Often transport coordinators lack the capabilities to do this, as their primary business requires different ones, so outsourcing tasks to external services is a reasonable and beneficial solution. Consequently, the way a transport coordinator does its typical tasks is changed and now incorporates these new roles.

The major change regarding the transport coordinator's role is the emergence of platform-based business models. As described above, platform-based business models can be used by transport coordinators to search for transport operators with free capacity (*contract TO via platform*). At the same time, consignors or consignees might offer parts of their transport orders on such a platform instead of sending them to a transport coordinator (new arrows *Transport order* from consignor and consignee). However, the highest impact of platform-based business models is that they can also act as transport coordinators, leading to a new and hybrid role *platform-based transport coordinator*. Indeed, this new form of transport coordination is a threat to existing classical coordinators such as freight forwarders or third-party logistic providers. To not let platform-based models overtake the hybrid role, established transport coordinators have started to offer their own platforms and platform-based solutions (Baron et al. 2017; Graser et al. 2017).

Whatever the future developments will be, it has become apparent that a transport coordinator's role has changed during the last years due to increasing digitalization and the application possibilities of emerging technologies. These developments cannot be neglected and should be considered when planning a transport coordinator's future. The identified effects of digitalization and the derived overview of emerging changes to the picture of the road freight industry (as depicted in Fig. 2) can help understand recent developments and their effects on transport planning. This understanding is pivotal to incorporate new and innovative technologies into transport planning successfully. Therefore, the presented results provide ground for future studies concerning where and how to integrate digitalization into transport planning.

6 Conclusion

This paper aims to examine digitalization effects on road freight transport planning and specifically on the transport coordinator. As a ground for this analysis, literature has been reviewed to clarify which actors typically play a role in road freight transport planning and how they are related to the transport coordinator. Next, scientific and

grey literature was analyzed to derive the main effects of digitalization on road freight transport planning: (1) new & more data sources, (2) new laws & regulation, (3) new & digital infrastructure, (4) new software & service provider, and (5) platform-based business models. The five identified effects were then transferred to the overview of roles. Roles and their relationship to the transport coordinator have been adapted accordingly. The relations to *facility & infrastructure providers* and *authorities* change due to the consideration of new infrastructure and new regulations. Moreover, three new roles – *data provider*, *software & service provider*, and *digital infrastructure provider* – were added due to their new relevancy for transport planning. The most significant adaptation is the addition of platform-based business models. They not only add a new form of relation for consignors, consignees, and transport operators, but they also provide ground for a new form of transport coordinators: the *platform-based transport coordinator*.

All digitalization effects and changes to roles and relationships have been discussed based on relevant scientific and grey literature. Consequently, both the viewpoints of research and practice are reflected in the results. However, the results should be validated and extended with expert interviews or similar. This way, it can be evaluated whether the literature reflects road freight transport's situation or whether further adaptations are needed. Future research should take care of this evaluation. Moreover, an extension of the examination towards the procedural level is an interesting idea. The effects of digitalization change not only roles and relationships but also the processes of transport planning. A more detailed analysis of the transport planning process and the process steps affected by digitalization can lead to a better understanding of how "digital transport planning" looks like and could be implemented. This deeper understanding could also be extended to other transport modes. While this paper focuses on road freight transport, some insights might be generalizable to other transport modes but would need to be adapted to their respective peculiarities.

References

Baldini, G., Sportiello, L., Chiaramello, M., Mahieu, V.: Regulated applications for the road transportation infrastructure: the case study of the smart tachograph in the European Union. Int. J. Crit. Infrastruct. Prot. **21**, 3–21 (2018). https://doi.org/10.1016/j.ijcip.2018.02.001

Baron, R., Zintel, M., Zieris, M., Mikulla, D.: Digital platforms in freight transportation. A true industry disruptor? Arthur D. Little (2017). https://www.adlittle.de/en/insights/viewpoints/digital-platforms-freight-transportation

Barua, L., Zou, B., Zhou, Y.: Machine learning for international freight transportation management: a comprehensive review. Res. Transp. Bus. Manag. **34**, 100453 (2020). https://doi.org/10.1016/j.rtbm.2020.100453

Bäumler, I., Kotzab, H.: Assessing research on intelligent transport systems for road freight transport from the viewpoint of different stakeholders. In: NOFOMA 2016 – Proceedings of the 28th Annual Nordic Logistics Research Network Conference (2016)

Belvedere, V., Grando, A.: ICT-enabled time performance: an investigation of value creation mechanisms. Product. Plan. Control **28**, 75–88 (2017). https://doi.org/10.1080/09537287.2016.1233359

Crainic, T.G.: Service network design in freight transportation. Eur. J. Oper. Res. **122**, 272–288 (2000). https://doi.org/10.1016/S0377-2217(99)00233-7

Crainic, T.G., Perboli, G., Rosano, M.: Simulation of intermodal freight transportation systems: a taxonomy. Eur. J. Oper. Res. **270**, 401–418 (2018). https://doi.org/10.1016/j.ejor.2017.11.061

Engholm, A., Björkman, A., Joelsson, Y., Kristoffersson, I., Pernestål, A.: The emerging technological innovation system of driverless trucks. Transp. Rese. Procedia **49**, 145–159 (2020). https://doi.org/10.1016/j.trpro.2020.09.013

eurostat: Freight transport statistics: European Union (2018). https://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics. Accessed 25 Jan 2021

Federal Ministery of Transport and Digital Infrastructure: Logistics 2030 Innovation Programme (2019). https://www.bmvi.de/EN/Topics/Mobility/Freight-Transport-Logistics/Logistics-2030-Innovation-Programme/logistics-2030-innovation-programme.html

Garousi, V., Felderer, M., Mäntylä, M.V.: Guidelines for including grey literature and conducting multi-vocal literature reviews in software engineering. Inf. Softw. Technol. **106**, 101–121 (2019). https://doi.org/10.1016/j.infsof.2018.09.006

Ghosh, S., Chowdhury, A., Ghosh, S.K.: A machine learning approach to find the optimal routes through analysis of GPS traces of mobile city traffic. In: Sa, P.K., Bakshi, S., Hatzilygeroudis, I.K., Sahoo, M.N. (eds.) Recent Findings in Intelligent Computing Techniques, vol. 708, pp. 59–67. Springer Singapore, Singapore (2018)

Graser, K., Krimpmann, D., Dehnhardt, G.: Digital Disruption in Freight and Logistics. Ready to roll? Accenture (2017). https://www.accenture.com/_acnmedia/pdf-53/accenture-digital-disruption-freight-logistics.pdf

Günther, H.-O., Seiler, T.: Operative transportation planning in consumer goods supply chains. Flex. Serv. Manuf. J. **21**, 51–74 (2009). https://doi.org/10.1007/s10696-010-9060-5

Heistermann, F., ten Hompel, M., Mallée, T.: Digitisation in Logistics. Answers to questions that concern companies. BVL (2017)

Hentschel, T., Haas, D., Farkas, M., Krotki, K., Umetova, N., Semmelmann, C.: Digitalization in Freight Forwarding. Beyond the Platform Hype. Deloitte (2019). https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-business/Deloitte_%20Digitalization%20in%20freight%20forwarding_PoV.pdf

Holcomb, M.C., Liao-Troth, S., Manrodt, K.B.: A shift in fundamentals. Transp. J **53**, 516 (2014). https://doi.org/10.5325/transportationj.53.4.0516

Holmgren, J., Davidsson, P., Persson, J.A., Ramstedt, L.: TAPAS: a multi-agent-based model for simulation of transport chains. Simul. Model. Pract. Theory **23**, 1–18 (2012). https://doi.org/10.1016/j.simpat.2011.12.011

Hsiao, H.I., Kemp, R., van der Vorst, J., Omta, S.: A classification of logistic outsourcing levels and their impact on service performance: evidence from the food processing industry. Int. J. Prod. Econ. **124**, 75–86 (2010). https://doi.org/10.1016/j.ijpe.2009.09.010

IRU: The future of road freight transport. IRU (2018). https://www.iru.org/resources/iru-library/future-road-transport

Ivanov, D., Tsipoulanidis, A., Schönberger, J.: Global supply chain and operations management A Decision-Oriented Introduction to the Creation of Value. Springer International Publishing, Switzerland (2017)

Jain, A., van der Heijden, R., Marchau, V., Bruckmann, D.: Towards rail-road online exchange platforms in EU-freight transportation markets: an analysis of matching supply and demand in multimodal services. Sustainability **12**, 10321 (2020). https://doi.org/10.3390/su122410321

Ji-Hyland, C., Allen, D.: What do professional drivers think about their profession? An examination of factors contributing to the driver shortage. Int. J. Logist. Res. Appl., 1–16 (2020). https://doi.org/10.1080/13675567.2020.1821623

Komiya, T., Shimakawa, Y., Goto, H.: A study on a routing problem focusing on freight transportations. In: Proceedings of the International Conference on Industrial Engineering and Operations Management (2019). Bangkok, Thailand, 5–7 Mar 2019

Korhonen, K., Kotavaara, O., Muilu, T., Rusanen, J.: Accessibility of local food production to regional markets – case of berry production in Northern Ostrobothnia, Finland. Eur. Countryside **9**, 709–728 (2017). https://doi.org/10.1515/euco-2017-0040

Liachovičius, E., Skrickij, V.: The challenges and opportunities for road freight transport. In: Gopalakrishnan, K., Prentkovskis, O., Jackiva, I., Junevičius, R. (eds.) TRANSBALTICA 2021. LNITI, pp. 455–465. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-38666-5_48

Mayring, P.: Qualitative content analysis. Forum: Qualitative Social Research 1, Art. 20 (2000). https://www.qualitative-research.net/index.php/fqs/article/download/3343/4445. Accessed 25 Jan 2021

Nicolaides, D., Cebon, D., Miles, J.: An urban charging infrastructure for electric road freight operations: a case study for Cambridge UK. IEEE Syst. J. **13**, 2057–2068 (2019). https://doi.org/10.1109/JSYST.2018.2864693

Pernestål, A., Engholm, A., Bemler, M., Gidofalvi, G.: How Will Digitalization Change Road Freight Transport? Scenarios tested in Sweden. Sustainability **13**(1), 304 (2021). https://doi.org/10.3390/su13010304

Ramstedt, L.: Transport policy analysis using multi-agent-based simulation. Blekinge Institute of Technology Doctoral Dissertation Series, vol. 9. Blekinge Institute of Technology, Karlskrona (2008)

Ramstedt, L., Woxenius, J.: Modelling approaches to operational decision-making in freight transport chains. In: NOFOMA 2006 –- Proceedings of the 18th Annual Nordic Logistics Research Network Conference (2006)

Ridouane Y, Herszterg I, Boland N, Erera A, Savelsbergh M (2020) Near real-time loadplan adjustments for less-than-truckload carriers. Optimization Online. http://www.optimization-online.org/DB_HTML/2020/01/7565.html. Accessed 25 January 2021

Riedl, J., Jentzsch, A., Melcher, N.C., Gildemeister, J., Schellong, D., Hofer, C., Wiedenhoff, P.: Why Road Freight Needs to Go Digital--Fast. Boston Consulting Group (2018). https://image-src.bcg.com/Images/BCG-Why-Road-Freight-Needs-to-Go-Digital_Fast-Apr-2018_tcm9-207932.pdf

Schaefer, T.J., Holcomb, M.C., Manrodt, K.B.: Will new tools fix our old problems? In: 27th Annual Study of Logistics and Transportation. Logistics Management (2018). https://www.logisticsmgmt.com/article/27th_annual_masters_of_logistics_will_new_tools_fix_our_old_problems. Accessed 25 Jan 2021

Schönberg, T., Pisoke, M., Illi, A., Hollacher, J.: FreightTech. Advancing the future of logistics. Roland Berger (2018). https://www.rolandberger.com/de/Insights/Publications/FreightTech-Die-Zukunft-der-Logistik.html

Schröder, M., Cabral, P.: Eco-friendly 3D-Routing: a GIS based 3D-routing-model to estimate and reduce CO_2-emissions of distribution transports. Comput. Environ. Urban Syst. **73**, 40–55 (2019). https://doi.org/10.1016/j.compenvurbsys.2018.08.002

Schroeder, S., Zilske, M., Liedtke, G., Nagel, K.: Towards a multi-agent logistics and commercial transport model: the transport service provider's view. Procedia Soc. Behav. Sci. **39**, 649–663 (2012). https://doi.org/10.1016/j.sbspro.2012.03.137

Seidenova, U., Hundenborn, J., Keuchel, S.: Costs and capabilities of innovative concepts of long and heavy vehicles in Germany. Res. Transp. Bus. Manag. 100518 (2020). https://doi.org/10.1016/j.rtbm.2020.100518

Seiler, T.: Operative Transportation Planning. Physica-Verlag HD, Heidelberg (2012)

Sigakova, K., Mbiydzenyuy, G., Holmgren, J.: Impacts of traffic conditions on the performance of road freight transport. In: 18th International Conference on Intelligent Transportation Systems. IEEE, pp. 2947–2952 (2015)

Stank, T.P., Goldsby, T.J.: A framework for transportation decision making in an integrated supply chain. Supply Chain Manag. **5**, 71–78 (2000). https://doi.org/10.1108/13598540010319984

Tavasszy, L.A., de Jong, G.: Introduction. In: Tavasszy, L.A., de Jong, G. (eds.) Modelling Freight Transport, 1st edn. Elsevier (2014)

Thomé, A.M.T., Scavarda, L.F., Scavarda, A.J.: Conducting systematic literature review in operations management. Prod. Plan. Control **27**, 408–420 (2016). https://doi.org/10.1080/09537287.2015.1129464

Wang, Y., Potter, A., Naim, M.: Electronic marketplaces for tailored logistics. Ind. Manag. Data Syst. **107**, 1170–1187 (2007). https://doi.org/10.1108/02635570710822804