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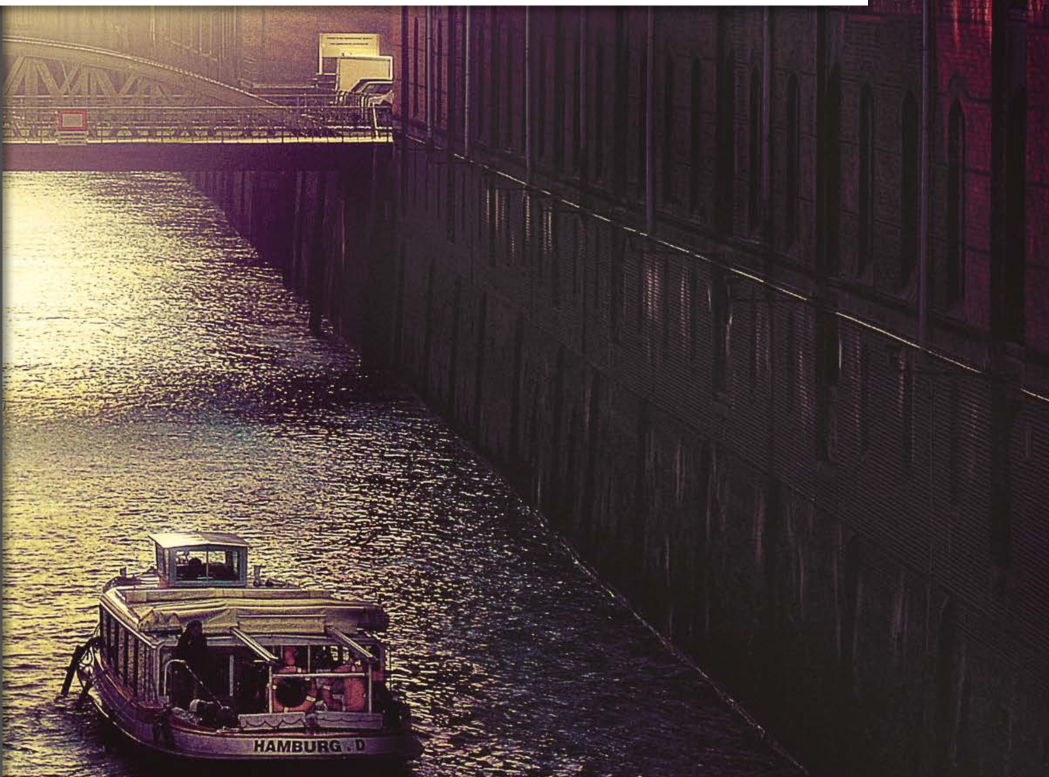

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Comparative Analysis of Synchromodality in Major European Seaports

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Global container throughput recorded a substantial growth over the past 25 years. The ports of Rotterdam, Hamburg and Antwerp have benefited greatly from this development. At the same time rapid increases can be observed for the dimensions of container vessels calling these ports. In 2005 the average capacity of container vessels in operation between Northern Europe and Far East amounted to 6,000 TEU. Today market actors already talk about container vessels with a capacity of 24,000 TEU. (ITF, 2015) This development provides a challenge for seaports concerning the water-side and landside accessibility. According to UVHH (2014) a rising amount of Ultra Large Container Vessels in the Port of Hamburg bears the risk of an increasing number of peaks and bottlenecks within the container terminals. These fluctuations will be continued at the interface to hinterland transport modes and to the connections to hinterland regions. By intelligently combining and switching between different transport modes the concept of synchromodality could form a solution for improving hinterland transportation and reducing bottlenecks in the seaports. (Tavasszy et al., 2015) This paper analyses the degree of implementation of synchromodality in major European container ports with special focus on the Port of Hamburg.

Keywords: Synchromodality; Maritime logistics; Hinterland transport chains; Collaborative networks

1 Introduction

Global container throughput recorded a substantial growth over the past 25 years. The ports of Rotterdam, Hamburg and Antwerp have benefited greatly from this development. The Port of Hamburg's container throughput e.g. increased by more than 451 % from just under 1.98 million Twenty-foot Equivalent Unit (TEU) in 1990 to almost 8.93 million TEU in 2016. (Statistisches Amt für Hamburg und Schleswig-Holstein, 2017) At the same time the Port of Antwerp recorded an increase in handled container volumes of almost 648 % from 1.55 million TEU in 1990 to about 10.04 million TEU in 2016. During the same period of time the Port of Rotterdam's container volumes increased by more than 338% from 3.67 million TEU to 12.39 million TEU. (Statistisches Amt für Hamburg und Schleswig-Holstein, 2017)

Similar rapid increases can be observed for the dimensions of container vessels calling these ports. In 2005 the average capacity of container vessels in operation between Northern Europe and Far East amounted to 6,000 TEU. The average capacity increased to 10,000 TEU in 2013 and is still increasing. (ITF, 2015) According to ITF (2015) shipping lines have ordered vessels with even larger nominal capacities. Already today market actors talk about container vessels with a capacity of 24,000 TEU and above. Ocean Shipping Consultants and Lloyds Register already conducted a feasibility study on such container vessels. (ITF, 2015)

The described development of the world container vessel fleet provides a challenge for seaports. On the one hand this concerns the nautical accessibility as well as the dimensions of berths. On the other hand increasing vessel dimensions and capacities are challenging container terminals and the connections to the hinterland. According to UVHH (2014) a rising amount of Ultra Large Container Vessels (ULCV) in the Port of Hamburg bears the risk of an increasing number of peaks and bottlenecks. These fluctuations will be continued at the interface to hinterland transport modes and to the connections to hinterland regions. Port and infrastructure extensions could form a solution to this. However, due to scarce space reserves an expansion of infrastructure and terminal capacities can hardly be realized in the large European seaports. Hence, Notteboom and Rodrigue (2005) refer to growing interdependencies between the seaports and terminals in the hinterland. A collaboration of seaports and inland terminals could help to overcome peaks and bottlenecks. (Notteboom and Rodrigue, 2005) The concept is further developed to an Extended Gateway Concept by Veenstra et al. (2012). Synchromodality bases upon the Extended Gateway Concept and thus, could form a solution smoothing the peaks and reducing the bottlenecks resulting from continuously growing container vessel sizes.

In this paper the degree of implementation of synchromodality in major European container ports is analyzed. For this an extensive literature review has been carried out in 2016 in order to define synchromodality in a first step. Afterwards the general definition of synchromodality is transferred to the maritime transport chain. In a third step the degree of implementation of synchromodality in major European container ports is analyzed with special focus on prerequisites of synchromodality in maritime transport chains. Finally, conclusions are drawn summarizing the results and evaluating the chances and state of synchromodality in the Port of Hamburg.

2 Synchromodality – The next generation of multimodal transportation

Generally spoken, synchromodality is a relatively young term that is not officially defined so far. The concept is part of the long-term vision of the Physical Internet until 2050 (alice, 2015). First usages can be found in the grey literature in 2010 e.g. the publication of a project report by the Dutch research institute TNO on behalf of the Dutch Ministry of Infrastructure and Environment. (Tavasszy et al., 2010) According to Tavasszy et al. (2010) synchromodality means an integrated transport solution (for a larger group of companies) where the optimal transport mode and available capacity is used at all times. One or more coordinators of complete transport chains or transport chain sections are monitoring the synchromodal transport chain. The mode choice decision is continuously checked. It will be then dynamically adjusted if there is a new 'best transport mode'.

Since the first use of the term synchromodality in the grey literature different definitions arose. (van der Burgh, 2012) Although the term synchromodality is gaining popularity in academic publications, no final and consistent definition exists so far. (Pleszko, 2012; van der Burgh, 2012;van Riessen, 2013; Reis, 2015; Tavasszy et al., 2015) In order to define synchromodality, in a way that integrates all aspects of synchromodality discussed in the grey and scientific literature, a total of 23 publications have been analyzed. (Tavasszy et al., 2010; ECT, 2011; Tavasszy et al., 2011; van Stijn et al., 2011; van Wijk et al., 2011; Verweij, 2011; Douma et al., 2012; Pleszko, 2012; van der Burgh, 2012; Li et al., 2013; van Riessen et al., 2013a; van Riessen, 2013; van Riessen et al., 2013b; Roth, 2013; Behdani et al., 2014; DHL, 2014; Knol et al., 2014; SteadieSeifi et al., 2014; alice, 2015; Putz et al., 2015; Reis, 2015; Tavasszy et al., 2015; TKI DINALOG, no date)

In this paper synchromodality is defined by the authors in high conformity with Putz et al. (2015) as follows: 'Synchromodality is at the actual time of performance the most efficient and most appropriate transport solution in terms of transport costs, duration as well as sustainability. Within the concept of synchromodality the configuration of the transport chain is not pre-defined before the transport starts but flexible. Thus, the configuration of the transport chain (mode choice) can be adapted according to the infrastructural and capacitive conditions at the actual time of transportation. This is made possible through a collaboration of all transport modes, the required terminal facilities as well as other actors involved that exchange real-time information on capacities and schedules. Thereby the collaboration is under the governing of a central institution that monitors the interactions between the different actors as well as provides the necessary information technology infrastructure.'

The majority of the analyzed publications consider synchromodality as the latest stage of development of still developing modality concepts. (Tavasszy et al., 2011; Verweij, 2011; Pleszko, 2012; Behdani et al., 2014; Putz et al., 2015; Tavasszy et al., 2015) The differences between the different concepts are partly just marginal. (SteadieSeifi et al., 2014; Reis, 2015) As an example, according to SteadieSeifi et al. (2014) the concept of multimodality includes all other modality concepts. Thus, the authors only use the term multimodality in their research paper. Reis (2015) also mention the co-existing and overlapping definitions for the different modality concepts. For a greater clarity Reis (2015) carried out an extensive literature analysis in order to be able to clearly define and differentiate the terms multimodality, intermodality, combined transport, co-modality and synchromodality. It is not explicitly stated whether co-modality and synchromodality require the use of at least two different transport modes. Pleszko (2012) also mentions co-existing definitions and defines synchromodality as a "multimodal transport policy at a higher level of process organization […], based on combinations of co-modal transport with proper scale of individualized solutions". In this definition co-modality allows the use of one transport mode only if this is the most efficient solution.

According to Tavasszy et al. (2015) and Behdani et al. (2014) synchromodality can be differentiated from the other modality concepts due to a higher degree of process organization. Following the authors' argumentation synchromodality is characterized by a dual integration that is no attribute of the other modality

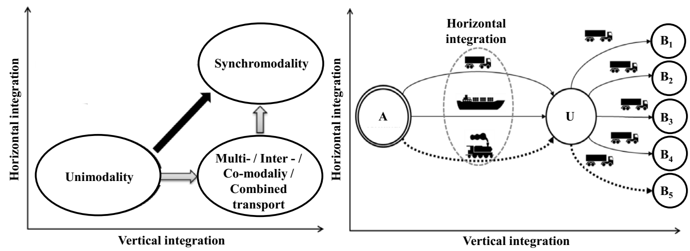

Figure 1: Dual integration as distinction criteria of synchromodal transport (authors based on Behdani et al. 2014)

concepts. This is illustrated in figure 1. According to Tavasszy et al. (2015) and Behdani et al. (2014) the vertical and at the same time horizontal integration of different transport modes leads to a coherent transport product with an improved service level for the shipper and a better use of resources concerning the different transport modes and transport sections. Tavasszy et al. (2015) describe synchromodality or synchromodal intermodality as a vision of a network of synchronized and connected transport modes that collaboratively meet the aggregated transport demand and align to the individual and current needs of the users of the transport network. As shown in figure 1 and in accordance with Tavasszy et al. (2015) and Behdani et al. (2014) this includes transport chains where the truck can be used between origin A and terminal U as well as between terminal U and destinations B1 to B5. Following this definition synchromodality does not necessitate the use of different transport modes.

In the analyzed research papers there is also no consistency concerning the scope of the definitions for synchromodality. The definitions in the analyzed research papers and publications can be divided into four groups as shown in table 1.

The chosen scope of synchromodality defines which actors are identified as relevant and which roles are assigned to these actors. This becomes clear by e.g. comparing the definitions describing synchromodality as relevant for sections of a transport chain within a clearly defined area with definitions that describe synchromodality as relevant mostly for the pre- and post-haulage of maritime transports. In the first case operators of sea terminals do not have a significant role. In the second case operators of sea terminals are key actors of synchromodal transport chains (terminal operator's haulage). (Tavasszy et al., 2015)

Table 1: Classification of definitions for synchromodality

Scope	References
Definitions that do not mention the scope of synchromodality within the transport chain.	Tavasszy et al., 2010; SteadieSeifi et al., 2014; Reis, 2015; TKI DINALOG, no date
Definitions that describe synchromodality as relevant for all sections of a transport chain between shipper A and consignee B.	ECT, 2011; Verweij, 2011; Douma et al., 2012; Li et al., 2013; Roth, 2013; DHL, 2014;
Definitions that describe synchromodality as relevant for sections of a transport chain within a clearly defined area.	van der Burgh, 2012;alice,2015
Definitions that describe synchromodality as relevant mostly for the pre- and post-haulage of maritime transports.	Tavasszy et al., 2011; Pleszko, 2012; van Riessen, 2013; van Riessen et al., 2013a, 2013b; Behdani et al., 2014; Knol et al., 2014; Putz et al., 2015; Tavasszy et al., 2015;

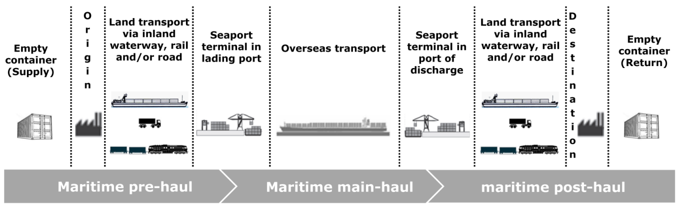

Figure 2: Sections of a maritime transport chain (authors based on Schönknecht 2009, Grig 2012 and Walter 2015)

3 The vision of the synchromodal seaport hinterland transport chain

In order to describe the vision of the synchromodal seaport hinterland transport chain the maritime transport chain is described in a first step. A transport chain can be described as a sequence of different processes and relationships of a loading unit with resources necessary for carrying out the transport. (Schönknecht, 2009) Transport chains that include waterborne transport can be summarized as maritime transport chains. The general structure of a maritime transport chain is illustrated in figure 2.

As can be taken from figure 2 the maritime transport chain consists of a maritime pre-haul (supply of empty container, loading of container as well as land transport), a maritime main-haul (handling of container at seaports and overseas transport) and a maritime post-haul (land transport, unloading of container and return of empty container). (Schönknecht, 2009; Grig, 2012; Walter, 2015)

The targets of synchromodality depend on the considered scope (within the fields of logistics). The targets of synchromodality as a concept for maritime transport chains are derived from the targets of synchromodality in general as described by ECT (2011), van Wijk et al. (2011), Verweij (2011), Douma et al. (2012), Pleszko (2012), van der Burgh (2012), Li et al. (2013), van Riessen (2013), van Riessen et al. (2013a), van Riessen et al. (2013b), Behdani et al. (2014), SteadieSeifi et al. (2014), Putz et al. (2015), Reis (2015) and Tavasszy et al. (2015). In order to make hinterland transportation more efficient the realization of synchromodality aims at achieving the following targets:

— Reduction of the total costs for transport, handling, storage, capital commitmentand charges

— Reduction of other logistics costs than transport, handling, storage, capital commitment and charges by

… an increased resilience within the maritime pre- and post-haul;

… an increased reliability of the maritime pre- and post-haul;

… an increased flexibility within the maritime pre- and post-haul;

… an increased responsiveness within the maritime pre- and post-haul;

… an improved service quality across the whole maritime transport chain;

— Increase of sustainability across the whole maritime transport chain and

— Coping the growth in transport volumes by an improved use of infrastructure

Van Riessen (2013), van Riessen et al. (2013a), van Riessen et al. (2013b) and Tavasszy et al. (2015) explicitly state that the reduction of transport and handling costs is a target of synchromodality. According to them the flexible combination of different transport modes within a clearly defined network leads to time and cost advantages. This is illustrated in figure 3.

The hexagons represent the price and duration of transport modes in unimodal transport chains. The squares T1 to T4 symbolize intermodal transport chains via the terminals 1 to 4 that are either cheaper or faster than unimodal transports. The circles T5 to T7 mean intermodal transport chains via the terminals 5 to 7 that are neither less expensive nor faster than the unimodal transport solutions. Following the argumentation of van Riessen (2013), van Riessen et al. (2013a), van Riessen et al. (2013b) and Tavasszy et al. (2015) the flexible combination of different intermodal transport chains within a synchromodal network leads to a variety of synchromodal solutions that are faster and less expensive than unimodal transport chains and that complement existing intermodal transport chains. The line represents the mentioned complementation of existing intermodal transport chains. The hatched area corresponds to the added value of synchromodal transport services compared to unimodal transport solutions.

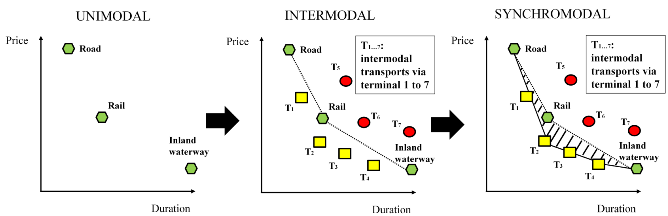

Figure 3: Temporary and/or price advantage of synchromodal networks (authors based on Tavasszy et al. 2015)

However, several aspects of maritime logistics counteract the concept of synchromodality. Examples for this are contractual regulations concerning e.g. quotas for individual transport modes. Each of the existing organization forms (e.g. merchant's haulage, carrier's haulage or terminal haulage) has its own special focus on the costs and organization of hinterland transportation. These restricted scopes – expressed within the existing tariff structures – lead to a limitation of flexibility required for synchromodal transport flows.

4 Degree of implementation of synchromodality in major European container ports

In order to achieve the objectives of synchromodality in maritime transport chains certain prerequisites need to be fulfilled. These are derived from the different definitions for synchromodality and are as diverse as these. Putz et al. (2015) classify the prerequisites for synchromodality into seven categories. As shown in table 2 these categories can be summarized to four main categories due to overlapping characteristics (based on Putz et al., 2015).

The term synchromodality is known in the Port of Hamburg but not implemented. This is the result of discussions carried out with market actors in 2016. Nevertheless, almost all actors referred to projects in Hamburg that could fit to single aspects of synchromodality. Further, actors associated synchromodality with the Ports of Rotterdam and Antwerp. Hence, the degree of implementation of synchromodality in these ports is analyzed. The question to be answered is, whether the whole concept of synchromodality or only single aspects are realized in these ports and what distinguishes these ports from the Port of Hamburg.

Answers to this question were found by carrying out an extensive literature review (especially publications by and about the Port of Hamburg, the Port of Rotterdam and the Port of Antwerp). The results are summarized in table 3.

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Table 2: Identified prerequisites for synchromodality

Title	Description
Physical network/ connections	Dense and reliable network of nodes (seaports and multimodal hinterland terminals and inland ports) and transport links (roads, railways and inland waterways) (Douma et al., 2012; Tavasszy et al., 2015)
Real-time data/(partly) automated transport planning	Consideration of "[…] uncertainty, traffic at terminals or en route, resource limitations and modal capacities" (SteadieSeifi et al., 2014, p. 14); Central information and communication platform for sharing up-to-date information (ECT, 2011; van Wijk et al., 2011; Pleszko, 2012; Behdani et al., 2014; Tavasszy et al., 2015).
Collaborative networks/trust	Cooperativeness and willingness to share real-time information; This includes the collaboration of shippers as well as logistics service providers. (Verweij, 2011; Douma et al., 2012; Pleszko, 2012; Behdani et al., 2014; Tavasszy et al., 2015) The information exchange requires trust between the involved actors. Governance mechanisms within the collaborative network can support building a solid basis of trust. (Mason et al., 2007; Pleszko, 2012; Pomponi et al., 2015) Further, synchromodality requires a different initiation of business where the organization of the transport chain is not predetermined. (van Wijk et al., 2011; Douma et al., 2012; Reis, 2015; Tavasszy et al., 2015)
Legal and political framework conditions	Horizontal collaborations need to be allowed under competitive law. (Tavasszy et al., 2015) Further, transportation regulations need to be harmonized, hampering rules and laws need to be eliminated and the legal framework needs to be revised concerning liability issues and the transfer of liability. (van Wijk et al., 2011; Pleszko, 2012; Tavasszy et al., 2015)

Table 3: Aspects of synchromodality in the major European container ports (authors based on UNICONSULT 2009a, 2009b; Eurogate and HHLA 2010; ECT 2011; van Wijk et al. 2011; Douma et al. 2012; MSC 2013; van Riessen 2013; van Riessen et al. 2013a, 2013b; Behdani et al. 2014; Port of Antwerp 2014)

Port of …	Rotterdam	Antwerp	Hamburg
Physical network/ connections	→	→	→
Real-time data/(partly) automated transport planning	↑	→	→
Collaborative networks/ trust	→	No (sufficient) information found	↓
Legal and political aspects	↑	↑	↑

↑ full compliance → partical compliance ↓ no compliance with prerequisites

aspects are realized in these ports and what distinguishes these ports from the Port of Hamburg.

Answers to this question were found by carrying out an extensive literature review (especially publications by and about the Port of Hamburg, the Port of Rotterdam and the Port of Antwerp). The results are summarized in table 3.

Table 3 none of the analyzed ports completely complies with all prerequisites. The Port of Rotterdam brands itself as a synchromodal port (ECT, no date) where the hinterland transport is organized by European Gateway Services (EGS) via the organization form terminal operator's haulage: For each trip to the hinterland region the modal choice is based upon the most efficient and sustainable solution and modes of transport can be immediately changed. (EGS, no date) Extended Gateway Terminals and adapted customs legislation allow the transport of containers directly into the Extended Gateway Terminals without customs audits procedures directly in the Port of Rotterdam. Although the Port of Rotterdam brands itself as a synchromodal port the network of Extended Gateway Terminals is still too small. The complete underlying synchromodal network comprises of in total 25 terminals in six countries. (ECT, no date) Thus, not all hinterland transports can be organized in a synchromodal way. Further, EGS, the logistics service provider offering synchromodal transports, is an ECT company. (EGS, no date) Hence, there is no real competition or collaboration of different logistics service providers, but all transports are organized by vertically integrating different logistics service providers. For the Port of Rotterdam case synchromodality is just realized within a clearly delimited geographic area and with regard to ECT only within one organizational entity (EGS as an affiliated entity of ECT). For all that, the Port of Rotterdam can be identified as one of the most open minded ports with regard to new collaboration forms. Although there is no collaboration of different logistics service providers a unique degree of collaboration between shippers respectively consignees and the transport organizing entity has been applied within a pilot study at the Port of Rotterdam. (Douma et al., 2011)

The Port of Antwerp also shows aspects of synchromodality, but the port does not brand itself as a synchromodal port. Like the Port of Rotterdam the Port of Antwerp also features a network of Extended Gateway Terminals especially in the region of Flanders. (UNICONSULT, 2009a) The Port of Antwerp as well as the Port of Rotterdam run Port Community Systems (PCS) that are used for the communication between the different actors involved in the transport chains via these ports. These PCS can be understood as a starting point for information and communication platforms for real-time information sharing as needed for synchromodal transport chains. (Port of Antwerp, 2014; UNICONSULT, 2009a) Further, the overarching goal of the advancement of the Port of Rotterdam's PCS Portbase (joint PCS of the Port of Rotterdam and the Port of Amsterdam) is a national PCS with key function in national and international port related logistical networks. This complies with the prerequisite of a central information and communication platform for sharing up-to-date information. (van Wijk et al., 2011; ECT, 2011; Pleszko, 2012; Tavasszy et al., 2015)

Compared to the Port of Rotterdam and the Port of Antwerp synchromodality is least developed in the Port of Hamburg. As shown in The term synchromodality is known in the Port of Hamburg but not implemented. This is the result of discussions carried out with market actors in 2016. Nevertheless, almost all actors referred to projects in Hamburg that could fit to single aspects of synchromodality. Further, actors associated synchromodality with the Ports of Rotterdam and Antwerp. Hence, the degree of implementation of synchromodality in these ports is analyzed. The question to be answered is, whether the whole concept of synchromodality or only single aspects are realized in these ports and what distinguishes these ports from the Port of Hamburg.

Answers to this question were found by carrying out an extensive literature review (especially publications by and about the Port of Hamburg, the Port of Rotterdam and the Port of Antwerp). The results are summarized in table 3.

Table 3, the conditions in the Port of Hamburg do not comply with the named prerequisites. As described above a dense and reliable network of nodes (seaports, multimodal terminals and inland ports) and transport links (roads, railways, inland waterways) forms a prerequisite for synchromodality. In the study 'hinterland gateway concept as relief for the Port of Hamburg' UNICONSULT (2009a) analyzed the demand for a network of hinterland terminals for the Port of Hamburg. They concluded that the hinterland gateway concept needs to be realized in the medium- and long-term in order to secure the Port of Hamburg's competitiveness. The two large container terminal operators in the Port of Hamburg Eurogate and Hamburger Hafen und Logistik AG (HHLA) even founded the Inland Port Network (IPN) in order to develop and implement an integrated strategy for maritime hinterland transports and terminals. (Schiffer and Jürgens, no date) The joint venture failed due to decreasing container volumes and therefore reduced bottlenecks in the Port of Hamburg.

Nevertheless, approaches exist in the Port of Hamburg in order to implement a central information and communication platform for sharing up-to-date information. The existing PCS forms a starting point for this. E.g. as part of the Port of Hamburg's PCS the Import Message Platform (IMP) is an intelligent electronic platform, enabling information to be exchanged between involved actors. (DAKOSY, no date) Though, it does not contain real-time traffic data in the port area. With the project smartPORT logistics the Hamburg Port Authority (HPA) aims at increasing the efficiency of the port as an important link in the supply chain by developing smart traffic and trade flow solutions. (HPA, no date) The project focusses on infrastructure, traffic and trade flows and pursues the following overriding objectives:

- "Managing and using the existing infrastructure in the Port of Hamburg in an efficient manner
- Reducing traffic-related emissions of air pollutants and greenhouse gases
- Establishing intelligent infrastructure in the Port of Hamburg
- Optimizing the flow of information to manage trade flows efficiency (HPA, no date, p. 2)"

Currently, the project is further developed to an international network of connected smart ports. (Brümmerstedt et al., 2017) As part of its smartPORT logistics initiative the HPA develops applications for better provisioning of up-to-date traffic data for truck drivers and dispatchers. This data comprises the traffic situation in the Port of Hamburg and on the highways, closure times of movable bridges and additional infrastructure information. It also includes the traffic situation at important actors like e.g. empty container depots and container terminals and information about the availability of parking lots for trucks. (HPA, no date)

However, so far only the port area and relevant connections are included in this project. Thus, port traffic within the Port of Hamburg will be improved only. For synchromodal hinterland solutions hinterland terminals and transport modes and routes outside the port area need to be included as well.

Three main framework conditions hampering the introduction of synchromodality in the Port of Hamburg can be identified:

- In contrast to the Port of Rotterdam (besides of Hapag Lloyd at the Container Terminal Altenwerder (share of 25.1%)) no dedicated terminal exists in the Port of Hamburg. Dedicated terminals form a prerequisite for vertically integrated and synchromodal transport chains organized as terminal operator's haulage.

- Customs procedures and provisions hinder the fast transport of containers to the hinterland terminals as well as the flexible reaction of hinterland transports to short-term problems.

- The willingness to cooperate lacks and trust is missing between

    - … the shippers and liner shipping companies as well as ocean freight forwarders,

    - … the competing liner shipping companies and ocean freight forwarders and

    - … the liner shipping companies and the terminal operators in seaports.

Without removing these obstacles, synchromodality will hardly be implemented in the Port of Hamburg.

5 Conclusion

As discussed in the previous sections synchromodality seems to form a solution for improving hinterland transportation and reducing bottlenecks in seaports. But it is neither clearly defined nor completely realized in any of the analyzed ports so far. Nevertheless, the Port of Rotterdam shows the highest degree of implementation. Synchromodality has already led to improvements in the hinterland transport chains of the Port of Rotterdam. (ECT, no date) For a complete implementation of synchromodality four prerequisites need to be fulfilled:

Firstly, synchromodality requires a dense and reliable network of nodes (multimodal terminals) and transport links. (Douma et al., 2012; Tavasszy et al., 2015) Secondly, the actors and transport modes need to be connected via a central information and communication platform for sharing up-to-date information concerning traffic data, resource limitations and modal capacities. (ECT, 2011; van Wijk et al., 2011; Pleszko, 2012; Behdani et al., 2014; Tavasszy et al., 2015) Thirdly, synchromodality requires the cooperativeness and willingness of all actors to share real-time information. This includes the collaboration of shippers as well as logistics service providers. (Verweij, 2011; Douma et al., 2012; Pleszko, 2012; Behdani et al., 2014; Tavasszy et al., 2015) Finally, the legal and political framework conditions need to allow collaborations of companies which are inevitable for the concept of synchromodality. Further, transportation regulations need to be harmonized, hampering rules and laws need to be eliminated and the legal framework needs to be revised concerning liability issues and the transfer of liability. (van Wijk et al., 2011; Pleszko, 2012; Tavasszy et al., 2015)

The concept of synchromodality is a relatively new concept for the Port of Hamburg. Although synchromodality is not implemented in the Port of Hamburg, market experts indicated that parts of the concept of synchromodality would lead to a de-stressing of the Port of Hamburg's hinterland connections. These are especially an increased share of up-to-date information and a central information and communication platform, more collaboration between the actors of the transport chain as well as a dense network of hinterland terminals and the Extended Gateway Concept. The Extended Gateway Concept as well as a dense network of hinterland terminals already were about to get realized in the Port of Hamburg but efforts were discontinued due to decreasing container volumes and resulting from this reduced bottlenecks. The smartPORT logistics initiative forms a first step towards an increased sharing of up-to-date information. The project concentrates only on the Port of Hamburg and needs to include especially hinterland terminals in order to become an information and communication platform that could be used in a synchromodal context.

Putting everything in a nutshell, synchromodality could form a solution for optimizing seaport hinterland transports, reducing the dwell-times of containers in the Port of Hamburg, increasing the storage capacities of the container terminals within the Port of Hamburg and by that increasing the reactiveness to peaks in waterside container handling due to larger container vessels. However, there is still a long way to go for synchromodal hinterland transport chains in the Port of Hamburg. The Port of Rotterdam case shows, that smaller scale synchromodal concepts can be successfully implemented. Although synchromodality is part of the Physical Internet roadmap until 2050 it is unclear to what extend the concept of synchromodality will prevail in European seaports.

References

alice Alliance for Logistics Innovation through Collaboration in Europe (2015). *Corridors, Hubs and Synchromodality: Research & Innovation Roadmap*.

Antwerp Port Authority (2015). *Maritime cargo turnover - January - December 2014*.

Behdani, B., Y. Fan, B. Wiegmans, and R. Zuidwijk (2014). *Multimodal Schedule Design for Synchromodal Freight Transport Systems*.

Brümmerstedt, K., R. Fiedler, V. Flitsch, C. Jahn, H. Roreger, B. Sarpong, S. Saxe, and B. Scharfenberg (2017). *Digitalization of Seaports - Visions of the Future*. Stuttgart: Fraunhofer Verlag.

DAKOSY (2017). *IMP - Import Message Platform*.

DHL (2014). *Logistics Trend Radar: Delivering insight today. Creating value tomorrow! Version 2014*. Ed. by DHL Customer Sulutions & Innovation.

Douma, A., A. Veenstra, and K. Verwey (2012). *Een stip op de horizon synchromodal vervoer in 2020. Definitie, kansen en perspectieven*.

ECT (2011). *The future of freight transport. ECT's vision on sustainable and reliable European transport*.

ECT (2017). *Europas synchromodaler Dienstleister*.

Eurogate and HHLA (2010). *Hinterland-Terminals für die maritime Containerlogistik*.

European Gateway Services (2017). *Company Profile*.

Grig, R. (2012). *Governance-Strukturen in der maritimen Transportkette: Agentenbasierte Modellierung des Akteursverhaltens im Extended Gate*. Schriftenreihe Logistik der Technischen Universität Berlin Technische Universität Berlin. Berlin: Univ.-Verl. der Techn. Univ. Berlin.

Hamburg Port Authority [HPA] (2014). *Port of Hamburg - digital Gateway to the World*.

International Transport Forum (2015). *The Impact of Mega-Ships*.

Knol, A., B. Klievink, and Y.-h. Tan (2014). “Data Sharing Issues and Potential Solutions for Adoption of Information Infrastructures: Evidence from a Data Pipeline Project in the Global Supply Chain over Sea: Paper 40”. In: *BLED 2014 Proceedings 2014*. Ed. by Association for Information Systems AIS Electronic Library (AISeL).

Li, L., R. R. Negenborn, and B. de Schutter (2013). “A general framework for modeling inter-modal transport networks”. In: *2013 10th IEEE International Conference on Networking, Sensing and Control (ICNSC)*. [Piscataway, N.J.]: [IEEE], pp. 579–585.

Mason, R., C. Lalwani, and R. Boughton (2007). “Combining vertical and horizontal collaboration for transport optimization”. In: *Supply Chain Management: An International Journal* 12.3, pp. 187–199.

MSC (2013). *Extended Gateway: Bringing the port to your doorstep.*

Notteboom, T. and J.-P. Rodrigue (2005). “Port regionalization: Towards a new phase in port development”. In: *Maritime Policy and Manegement* 32.3, pp. 297–313.

Pleszko, J. (2012). “Multivariant configurations of supply chains in the context of synchromodal transport”. In: *LogForum Scientific Journal of Logistics* 8.4, pp. 287–295.

Pomponi, F., L. Fratocchi, and S. Rossi Tafuri (2015). “Trust development and horizontal collaboration in logistics: a theory based evolutionary framework”. In: *Supply Chain Management: An International Journal* 20.1, pp. 83–97.

Port of Antwerp (2014). *How does APCS work?*

Port of Rotterdam Authority, PIM, and CBL (2017). *Containers and TEU time series*.

Putz, L.-M., C. Haider, A. Haller, and O. Schauer (2015). “Identifying Key Enablers for Synchromodal Transport Chains in Central Europe”. In: *Proceedings of the WCTRS SIGA2 2015 Conference "The Port and Maritime Sector: Key Developments and Challenges"*.

Reis, V. (2015). “Should we keep on renaming a +35-year-old baby?” In: *Journal of Transport Geography* 46, pp. 173–179.

Roth, M. (2013). “Monitoring von Prozessinstanzen in logistischen Netzwerken”. In: *Beiträge zum 17. Interuniversitären Doktorandense-minar Wirtschaftsinformatik (IDS 2013)*. Ed. by J. Ruhland and L. Wenige, pp. 49–58.

Schiffer, E. and S. Jürgens (n.d.). *Hinterland-Terminals für die maritime Containerlogistik*.

Schönknecht, A. (2009). *Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten*. VDI-Buch. Berlin, Heidelberg: Springer Berlin Heidelberg.

Statistisches Amt für Hamburg und Schleswig-Holstein (2017). *Schifffahrt und Außenhandel Hamburgs 1970 bis 2016: STATISTISCHE BERICHTE G III/H II - j 16 HH (Sonderbericht)*.

SteadieSeifi, M., N. P. Dellaert, W. Nuijten, T. van Woensel, and R. Raoufi (2014). “Multimodal freight transportation planning: A literature review”. In: *European Journal of Operational Research* 233, pp. 1–15.

Tavasszy, L., B. Behdani, and R. Konings (2015). *Intermodality and Synchromodality*.

Tavasszy, L., R. Janssen, L. van der Lugt, and Lorike Hagdorn (2010). *Verkenning Synchromodaal Transportsysteem - hoofdrapport: In opdracht van: Ministerie van Infrastructuur & Milieu: TNO-034-DTM-2010-04431*.

Tavasszy, L., H. J. Quak, and R. Janssen (2011). “Orchestrating innovations in lo-gistics: mind your step”. In: *EVO’s Logistics Yearbook edition 2011*. Ed. by P. J. van der Sterre. Zoetermeer, pp. 19–27.

TKI DINALOG (2017). *Synchromodal*.

UNICONSULT (2009a). *Hinterland Gateway Konzept zur Entlastung des Hamburger Hafens: Im Auftrag der Hamburg Port Authority HPA*.

UNICONSULT (2009b). *Konzeptstudie zur Verkehrsverlagerung vom LKW auf Binnenschiffe und zur Stärkung der Hinterlandverkehre: Im Auftrag der Behörde für Wirtschaft und Arbeit der Freien und Hansestadt Hamburg*.

Unternehmensverband Hafen Hamburg e.V. (2017). *Hafen Hamburg: Jahresbericht 2014*.

van der Burgh, M. (2012). *Synchromodal transport for the horticulture industry: Requirements for implementation in the Westland-Oostland greenport: Master thesis at the Erasmus University Rotterdam*.

van Riessen, B. (2013). *Planning of hinterland transportation in the EGS network: Master's thesis Transport Engineering and Logistics (TU Delft) Operations Research & Quantitative Logistics (EUR)*.

van Riessen, B., R. R. Negenborn, R. Dekker, and G. Lodewijks (2013a). "Impact and relevance of transit disturbances on planning in intermodal container networks: (No. EI 2013-18)". In: *Econometric Institute Research Papers, Erasmus University Rotterdam*, pp. 1–23.

van Riessen, B., R. R. Negenborn, R. Dekker, and G. Lodewijks (2013b). "Service network design for an intermodal container network with flexible due dates/times and the possibility of using subcontracted transport: (No. EI2013-17)". In: *Econometric Institute Research Papers, Erasmus University Rotterdam*, pp. 1–16.

van Stijn, E., D. Hesketh, Y.-h. Tan, B. Klievink, S. Overbeek, F. Heijmann, M. Pikart, and T. Butterly (2011). *The Data Pipeline: Global Trade Facilitation Conference 2011: Connecting International Trade: Single Windows and Supply Chains in the Next Decade*.

van Wijk, L., L. Hagdorn, W. Versteijnen, and M. Dierikx (2011). *Partituur naar de top Adviesrapport Topteam Logistiek: Topteam Logistiek*.

Veenstra, A., R. Zuidwijk, and E. van Asperen (2012). "The extended gate concept for container terminals: Expanding the notion of dry ports". In: *Maritime Economics & Logistics* 14, pp. 14–32.

Verweij, K. (2011). "Synchromodal transport: Thinking in Hybrid Cooperative Networks". In: *EVO's Logistics Yearbook edition 2011*. Ed. by P. J. van der Sterre. Zoetermeer, pp. 77–88.

Walter, F. (2015). *Informationsaustausch in der maritimen Transportkette: Untersuchung der Prozessleistung im Datenfluss und der Kapazitätsauslastung*. SpringerLink : Bücher. Wiesbaden: Springer Gabler.