BUNDLING NETWORKS FOR INTERMODAL FREIGHT FLOWS TO THE EUROPEAN HINTERLAND

Arnošt Bartošek[1], René Schönemann[2]

Summary: This paper compares bundling concepts for various situations, and suggests the development of inland services contrary to the simultaneous situations. All matters are carried out for configuration and bundling in the Hamburg-Rotterdam range (H-R range), with focus on the bundling in rail networks, and bundling in barging networks of container flows to the central Europe. The challenge is to identify promising directions of intermodal network development.

Key words: intermodal transport, container, bundling, terminal,

INTRODUCTION

Containerization and developments of intermodal transport systems have led to a time-space approaching and made intermodal players revise and synchronize liner service schedules and associated hinterland networks. As a consequence, hinterland services have been modified by intensified competition among seaports and intermodal operators. Container transports have become more flexible from any inland location to any suitable port, that an ocean carrier or shipper is interested in. Market players in the maritime transport consider inland logistics as one of the most important areas still to improve economic indicators, to add value, and to increase profitability. In order to find efficient inland services, intermodal operators and shippers have come up with network solutions leading to new dynamics in transport system development. Transport actors periodically rethink their network in an attempt to improve or maintain transport quality and efficiency, and company profitability. The bundling of freight flows in transport nodes can be one of the motivating forces in this development. The advantages of a bundling concept lead to higher frequencies of services and destinations served, to an increase of the terminals served, and in higher load factors. The application of a bundling concept allows the finding of appropriate intermodal solutions for more situations and could also increasing intermodal competitiveness.

The purpose of this paper is focused on the presentation and simulation of bundling concepts within rail and barge transport in seaport-hinterland interactions that could lead to economic increase, managerial and technical efficiency of intermodal transport of containers. Work on the comparative analysis of bundling concept has been carried out both in the remote past as well as in the recent years, e.g. in (1) and (2). Selected issues (freight flows, exchange

[1] Ing. Arnošt Bartošek, Czech Technical University in Prague, Faculty of Transportation Sciences, Department of Logistic and Transportation Processes, Horská 3, 128 03 Prague, Tel.: +420607507292, E-mail: xbartosek@fd.cvut.cz

[2] Dipl.-Verk.wirtsch. René Schönemann, Berlin University of Technology, School V (Mechanical Engineering and Transport Systems), Department of Land and Sea Transport Systems, Salzufer 17 - 19, 10587 Berlin, Tel.:+4903031422710 E-mail: RSchoenemann@railways.tu-berlin.de

nodes etc.) have been further investigated in (3) and (4). Crucial attributes of bundling concepts and bundling networks are shown in Section 1-2. The analysis of bundling in the H-R range is explored in sections 3-5 and supported by a set of models subsequently. Final conclusions and implications are summarized in the end.

1. BUNDLING CONCEPT

Market players in the maritime transport consider inland logistics as one of the most important areas still improving economic indicators, to add value and to increase profitability. The so-called bundling concept is one of the possible solutions how to improve the intermodal transport and could also increase competitiveness. The application allows solving appropriate intermodal situations, such as route choice, bundling decision etc. (1). The concept of bundling can be used on relations where the container flows are not economical sufficient to fulfil a direct service. If small vehicle scales are acceptable, bundling is possible to use. Its utilization can be found in different flows (different origin and destination terminals), in common transport and/or load units during common parts of their routes. Among others, the advantages of bundling are:

- An increase in the transport frequencies which leads to reduce the waiting time at seaport/terminal.
- An increase in the number of destinations served from a terminal.
- An increase of profitability in terms of higher degrees of utilization and/or the utilization of larger transport units (TEU).

The bundling concept has some disadvantages as well:

- It causes additional handling at intermediate terminals, such as the exchange of load units between trains or barges. A possible countermeasure is the implementation of a fast transhipment technology.
- It sometimes causes an increase of transport distance and increase of transport time in comparison to the direct connection.
- The local branches have a restricted vehicle scale, making this part of the networks expensive.

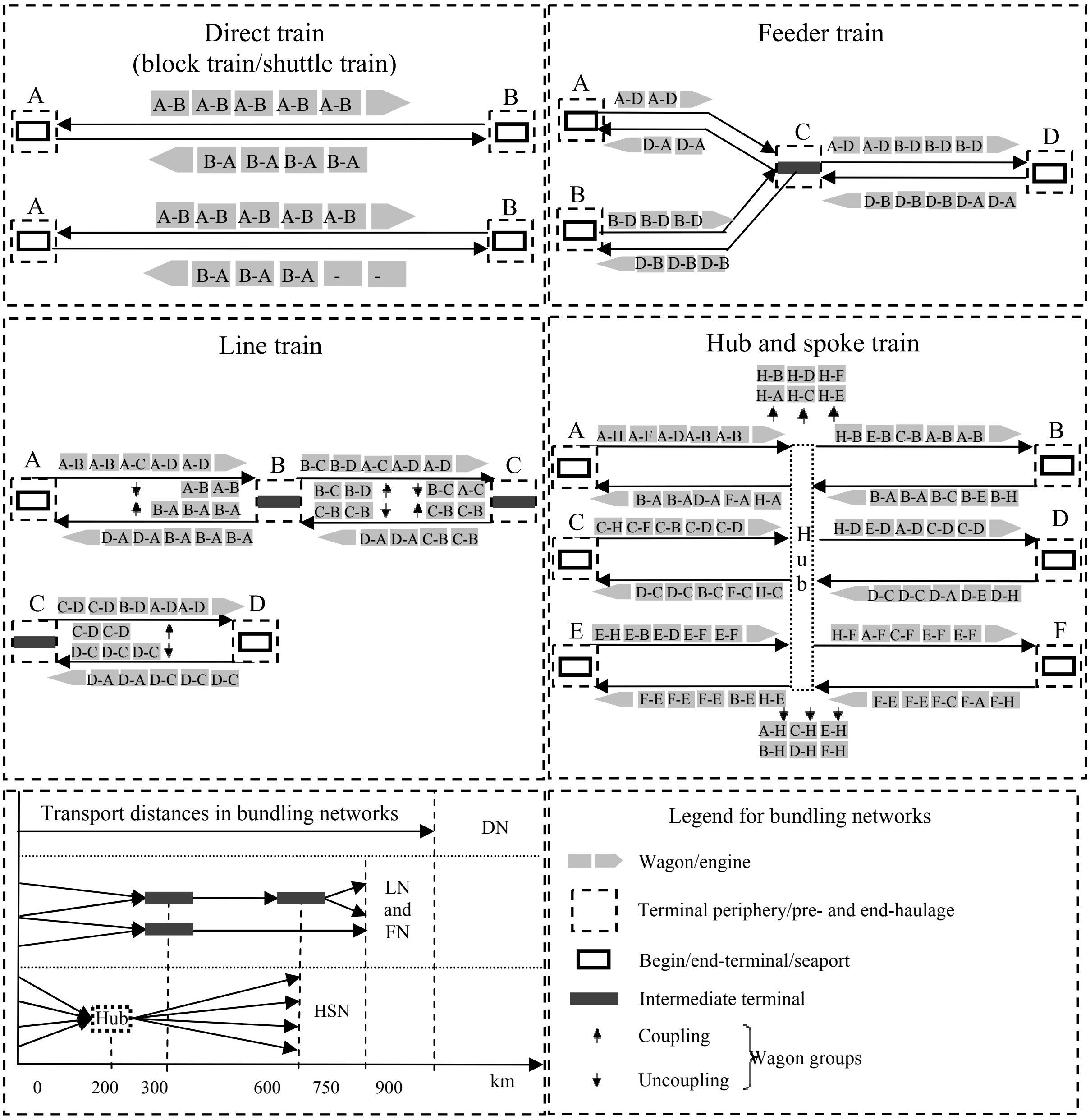
The precise bundling concept depends on the balance between the above-mentioned advantages and disadvantages and this balance in turn depends on the size of the network volume.

The bundling of freight flow is influenced by many factors such as:

- Service frequencies – service frequencies to/from hinterland destinations depend on the chosen route and the rotation of calls of container vessels in seaports.
- Loading capacity of transport units – the optimal size of vehicles depends on types of cargo, cargo volume, transit time etc.

- The number of stops at intermediate terminals – the number of stops depends on the service design related to a choice between a direct service between two loading points.

For a better comprehension of the bundling concept it is necessary to define different types of bundling networks/systems where containers are transported. There are direct network (DN), feeder network (FN), line network (LN) and hub and spoke network (HSN) as well as combinations of these (2). Networks are applicable for transport by rail in compact trains. Pivotal characteristic of trains in each network with an appropriate distance is shown in Fig. 1.



Source: Authors

Fig. 1 - Bundling networks/trains and transport distances

The most frequent and the easiest option is the so called direct train. This train is running between two terminals (begin/end) without transhipping on the way. It is the most economic and rapid mode of rail operation. There are two variants, block trains where the numbers of wagons depends on the specific demand and shuttle trains where the number of wagons is fixed, typically around 70-90 TEU (5). Those trains have regularly fixed schedules between two terminals. This option is usually used by operators for a specific customer. Shuttle trains in the European hinterland connections can only be exploited in a profitable way on a restricted number of high-density traffic corridors. Another possible system is the so called feeder train. If the demand of cargo volumes is too small for economical services with direct trains, feeder systems can be a possible solution. The aim of the feeder train is to link terminals of a smaller region with a central hub where several feeder trains will be assembled to longer trains for the main run. The containers are transported on the same wagons for the whole time of transport and transhipment is realised only at the origin and destination terminals. This option is usually used by services for two customers which have consignments for one end terminal. A currently rarely used system is the line train. It offers regularly scheduled services and allows the integration of terminals with smaller demands in a network of intermodal transport. The line train is characterized by a fixed composition of wagons which are coupled and uncoupled during the stops at intermediate terminal. The last system describes the hub and spoke train. This system is used mainly for connection between medium and small terminals with unequal container flows. All operations, such as transhipment, formation and bundling occur in the hub. Trains are gathered spokewise in terminals at a certain time. During this time the coupling of wagon groups is realized. If trains from different operators are gathered, it can be called a gateway system.

2. BUNDLING IN SEAPORT/INLAND TERMINALS

The transhipment at seaports and inland terminals plays an important role in bundling concepts, particularly concerning the total transport time. The seaport terminals serve as logistics gates to the hinterland. The volume transhipped at seaport terminals increases or decreases according to the frequency of container vessels calling, trucks arriving, train schedules and an overall flow of information. The speed of transhipment is highly depend on the spatial layout of the seaport area, operational characteristics, transhipment equipment, transport equipment, number of berths, depth of draught etc. (6). Concerning the container transhipment from and to trains in bundling concept it is necessary that the shunting yard is equipped with yard cranes such as rail mounted gantry. They allow rapid transhipment of large quantities of containers within a short time. One container move takes approximately 3 minutes (6). Likewise the track length in the container terminal of the seaport plays an important role as the optimum length would be around 650 m, which equals around 30 wagons per train. Nevertheless in the bundling concept plays a more important role for inland/intermediate terminals. These terminals can be either bimodal (rail-road) or trimodal (river-rail-road). They provide the space, the equipment, and the operational environment for transferring containers between the different transport modes. The general optimal/desired inland terminal should be disposed with parameters as follow:

- To have at least 3-4 transhipment tracks with useful length varied between 550-650 m; all tracks are passable, at the beginning and at the end with overhead lines.

- To have sufficient number of lay tracks (3-4).
- To have adequate storage area for containers - at least 40 000 m^2.
- To have facilities to enable two trains entering and leaving at the same time.
- To have at least 3 rail mounted gantry cranes (RMG) with span 40 m or more (3).

Optimal layout depends on chosen bundling network and volume of the container flows. The length of train is the crucial factor for the involvement of terminals into the networks. On the one hand, the usual length is about 550-600 m (see Tab. 1) but the highest figures exceed 700 m, which obviously 90% of inland terminals are not capable to accommodate. On the other hand, the length of useful tracks in terminals fluctuates between 200-700 m as well, which is particularly limited in Central Europe (5). These restrictions prevent the positioning of full trains directly under the gantry cranes and it limits the container transhipment rate. Likewise it is necessary mentioned, that the max. train length is defined by national infrastructure operators and differs for each country.

Tab. 1 - Usual length of shuttle trains (2012)

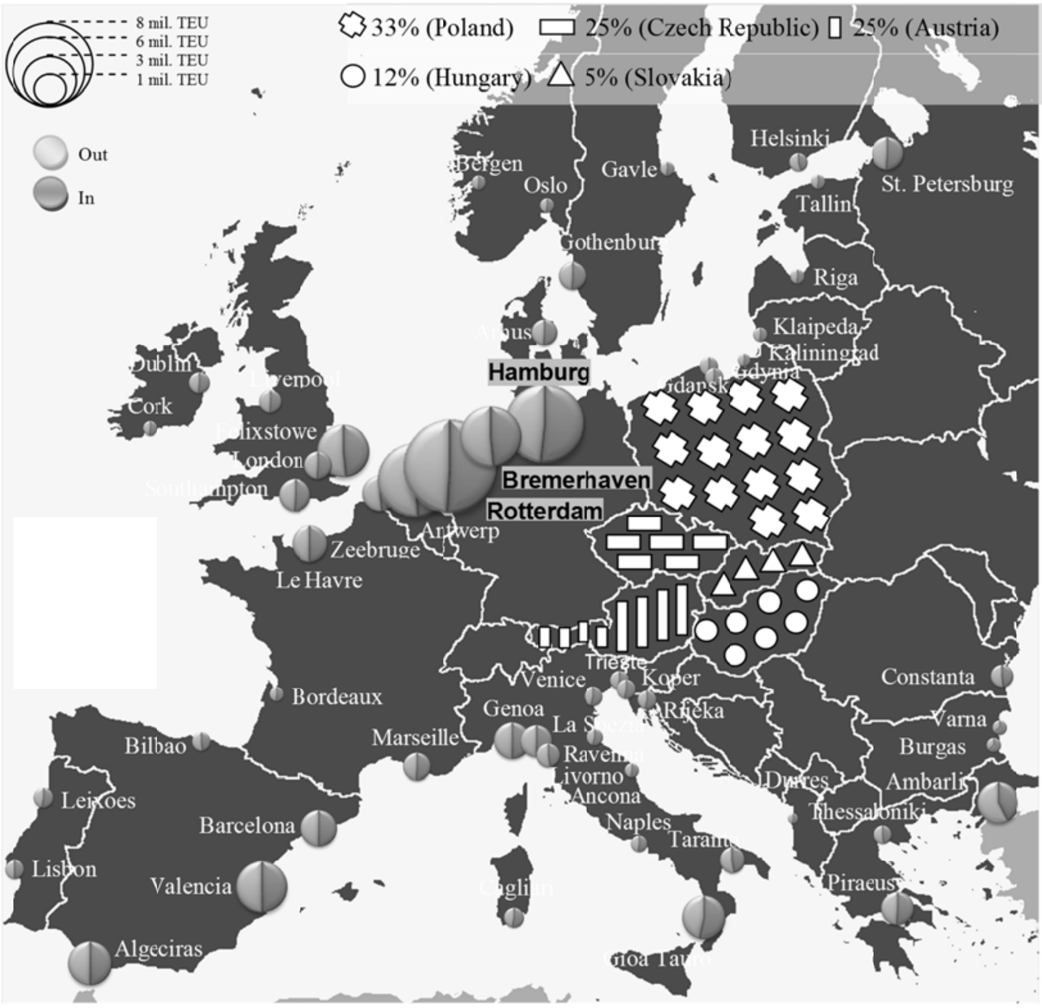
Indicator/operator	Bohemiakombi	AWT	Metrans	RailLogix
Train length (m)	480 (Duisburg)	600 (Bremerhaven)	607 (Hamburg)	550 (Rotterdam)
Train capacity (TEU)	65 (Duisburg)	82 (Bremerhaven)	92 (Hamburg)	75 (Rotterdam)

Source: (5)

3. BUNDLING IN SEAPORT/INLAND TERMINALS

Currently about 70% of containers in Europe are transported through seaports at the coast of the North Sea and the Atlantic Ocean. More precise, the major share of total container transhipment is divided among the large seaports of Rotterdam, Antwerp, Hamburg and Bremerhaven etc. (3), as shown in Fig. 2. Therefore, for the purpose of this article, the so-called H-R range is chosen. It includes the ports of Hamburg and Bremerhaven in Germany, and Rotterdam in the Netherlands. Currently large modern container vessels call mainly at North Sea ports, which - unlike as most Mediterranean ports - are sufficiently adapted for these vessels in both, terms of their maximum water depth and their container terminal quay length; in addition they possess a sufficiently advanced handling technology. In contrast, it becomes evident, that the transport of the containers from/to Central Europe (the Czech Republic, Slovakia, Hungary and Austria) is closer to southern Mediterranean ports from the geographical point of view. Despite of this, the Central European markets for quality reasons prefer to be served by northern ports either on road or railway basis.

The H-R ports serve primarily connections for Euro-Asian routes as well as access to feeder relations for Northern and Eastern Europe. Recently container vessels calling North Sea ports have enlarged their volume up to 14.000 TEU, see Tab. 2. Most mainline carriers running container vessel services from/to the H-R range stick to line bundling itineraries with calls scheduled in each of the main markets, that is, three to five regional load centres per loop (5).



Source: (5)

Fig. 2 - Major European seaports in terms of Container transhipment (2010) and the market share of Hamburg port in hinterland traffic to/from Central Europe (2011)

Tab. 2 - Connections of H-R ports with Far East (2012)

Carrier/alliance	Service	TEU capacity	No. of vessels
CKYH	NE 1	9.500-13.000	9
Loop/port rotation	*Hamburg – Rotterdam – Felixstowe – Singapore – Nansha – Shanghai – Ningbo – Hong Kong – Hamburg*		
MSC/CMA-CGM	Swan/FAL 3	11.400	11
Loop/port rotation	*Le Havre – Hamburg – Bremerhaven – Antwerp – Jeddah – Singapore – Xingang – Busan – Shanghai – Xiamen – Singapore*		
Maersk/CMA-CGM	AE-8/FAL 5	13.000-13.800	10
Loop/port rotation	*Le Havre – Rotterdam – Hamburg – Zeebrugge – Port Kelang – Singapore – Ningbo – Shanghai – Yantian – T.Pelapas*		

Source: (5)

The competitiveness of the transhipment centres in the range is mainly determined by the seaport's capabilities in dealing with container flows to the immediate and more distant hinterland regions. All above mentioned seaports compete among themselves for traffic to/from Germany, France, the Alpine region, northern Italy, Central, and Eastern Europe. As a characteristic example, Fig. 2 shows the Hamburg port market share for Central Europe. Seaports differ in technical parameters and different proportions of the traffic modes in the seaport itself (due to geographical and historical reasons), which is expressed by the modal split (7). Recently, there have been efforts to skip a higher share of transports to rail and inland waterways, in order to reduce disparities between different modes of transport. As the Tab. 3 indicates, the largest and the most balanced share in selected ports has been reported with the road transport, which is due to its high flexibility and its ability to provide door-to-door delivery. The highest share of railway transport has been reported by the seaport of Bremerhaven (43%), whereas other seaports show the European average. Also the feeder vessels transport to intermediate nodes plays an important role. Especially the North Sea ports use this transport for containers to Scandinavia, U.K., Ireland, France and Spain. The inland water transport accounts for very small or zero shares, which has been caused by a small number of navigable rivers into the European hinterland. The exception is the port of Rotterdam (23%), which uses Nieuwe Maase and Rhine rivers, as well as a number of river channels crossing the whole Benelux.

Tab. 3 - Modal Split at the transport of containers to the European hinterland (2011)

Seaport/mode	Road	Rail	Barge	Feeder
Hamburg	51%	27%	2%	20%
Bremerhaven	38%	43%	3%	16%
Rotterdam	44%	7%	23%	26%

Source: (6)

4. RAIL BUNDLING IN THE H-R RANGE

In Europe, in the contrary to North America and Asia, rail logistics is highly complex. A geographically, politically and economically divided Europe prevented the realization of greater intermodal economies of scale and scope. The backbone of rail services in the H-R range is formed primarily by direct shuttle trains. The rest of train services (from bundling concepts) comprise of only 20% from total volume. A big part of these shuttle trains in the EU mainly operate from/to inland terminals of combined transport or logistics hubs in Germany (Duisburg, Munich), Switzerland (Basel), France (Lyon) and Italy (Verona). Talking about the transport of containers on trains in Central Europe (Poland, the Czech Republic, Austria, Slovakia and Hungary), European intermodal operators are offering a smaller range of connections and train frequencies, see Tab. 4. New railway operators often try to enter the market by introducing competing direct shuttle trains on a spoke belonging to an established hub and spoke network of a competitor. A further decline of hub and spoke rail network in Europe could affect the future growth potential of smaller and new ports. Direct shuttle train services are often terminated within a time span of less than half a year because cargo availability is low or highly fluctuating. Some carriers and rail operators have resolved the problems related to the fluctuating volumes and the numerous final destinations by bundling container flows in centrally located nodes in the more immediate hinterland.

Tab. 4 - Selected shuttle trains of intermodal operators from/to Central Europe (2012)

Operator/ route (number of trains per week - export/import)	Hamburg/ Bremerhaven - Vienna	Hamburg/ Bremerhaven - Poznan	Hamburg/ Bremerhaven - Prague	Rotterdam-Prague	Hamburg/ Bremerhaven - Budapest
IMS (AT)	16/25				
Polzug (PL)		15/15			
Metrans (CZ)			48/46	3/3	
I.C.E. (HU)					5/5

Source: (5)

5. BARGE BUNDLING IN THE H-R RANGE

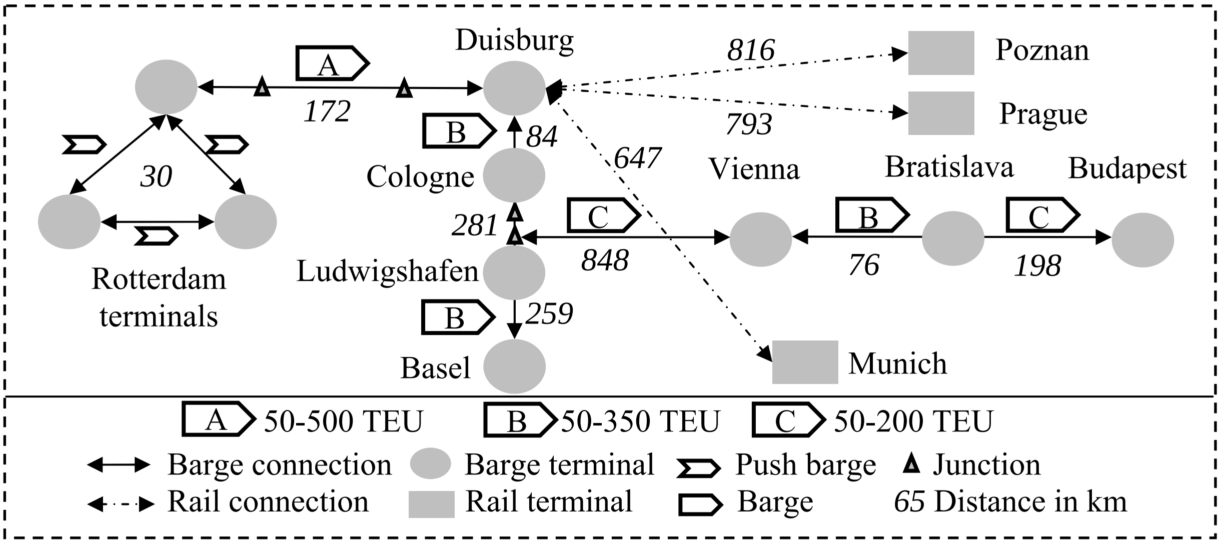
Barge container transport in Europe has its origins in transport between Antwerp, Rotterdam and the Rhine basin. Barge traffic is primarily concentrated in only two maritime load centres, Antwerp and Rotterdam. The transport of containers by means of barges to Central Europe is almost annihilated, except on the Danube. This is caused due to the bad navigability of many rivers such as Elbe and Oder. In addition, the barge capacity that can be deployed is restricted and not homogenous due to typical restrictions such as draft conditions and bridge heights along a river. These elements favour the use of line bundling systems. For example, the line service networks offered on the Danube are mainly of the bundling type calling at two to five terminals per navigation area with each rotation. The common capacity of barges on the Danube ranges from 48 to 488 TEU, see Tab. 5. Although, there is not a regular hub and spoke structure for barge container transport, the market is tending towards a large inland waterways hub from where the containers can be further distributed by other barges, rail or road transport.

Tab. 5 - Selected barge services to the Rhine terminals (2012)

Route/ Operator (number of barges per week - export/import)	Samskip (NL)	*Capacity per barge (TEU)*	Rhine container (NL)	*Capacity per barge (TEU)*	H&S Container Line (DE)	*Capacity per barge (TEU)*
Rotterdam-Duisburg	3/3	*208*	4/4	*336-488*	7/7	*48-400*
Rotterdam-Andernach					2/3	*48-400*
Rotterdam-Mainz			2/2	*268-368*		

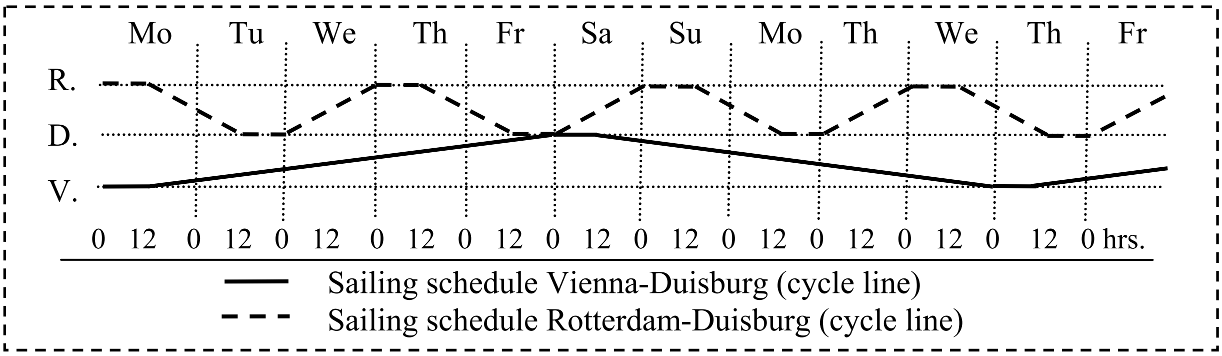
Source: (5)

As an example, the bundling combination of barges and trains can be proposed where several inland barge terminals along the Rhine and Danube serve as container exchange nodes for further connections to the more distant hinterland/Central Europe, see Fig. 3. This is especially suitable for empty containers which can be transported by the cheapest mean of transportation (barge) to/from the hinterland export areas. The concept is applicable to any other comparable situation. The Rhine-Danube example is illustrated by an example of a barge sailing schedule. The terminal time for all necessary operations in Rotterdam, Duisburg as well as in the port of Vienna is about 12 hours; the barge always calls only one terminal in each port. This makes a total cycle time of 72 hours for a 350 TEU barge in case of the connection Rotterdam-Duisburg. In case of the connection Vienna-Duisburg it makes 240 hours for a 200 TEU barge, see Fig. 4. While the barge is on its way to Vienna and back to Duisburg, the Rotterdam-Duisburg barge delivers containers for rail connection to the hinterland to Duisburg terminal. This example shows one of the most effective intermodal approaches in practice.



Source: Authors

Fig. 3 - Proposal of Rhine and Danube bundling corridors to the Central Europe



Source: Authors

Fig. 4 - Optimal Sailing schedule for bundling barges between Rotterdam and Vienna

CONCLUSIONS

The reorganization and reconfiguration of rail and barge shuttle services to the hinterland is a powerful economic stimulus for actors to redefine their role in landside operations. The bundling concept influences the performance of seaports with the development and performance of hinterland networks. The development of barge/rail services plays a major role in the bundling strategy. On the one hand, potentials of barge transport will be enhanced, if barge services can be linked to rail services to dry inland destinations. On the second hand, rail services will profit from links with barge services. The mutual advantages are higher loading degrees and higher transport frequencies. This will prove the price and quality of rail and barge services. In order to achieve the competitiveness of bundling, it is necessary to have adequate frequencies of train departures, with a fixed timetable and relevant rates at all stages of transport. There is no such thing as an ideal service for seaports and their connection to the hinterland. Each situation requires a separate study to determine the configuration that will provide the services best suited to market needs.

ACKNOWLEDGEMENTS

The research described in this article was established within the framework of the CTU student grant competition in 2011 No. SGS11/139/OHK2/2T/16 “Logistics operations within framework of container transhipment”.

REFERENCES

(1) KONINGS, R., PRIEMUS H., NIJKAMP, P., *The future of Intermodal Freight Transport*, Edward Edgar publishing Inc., 2008. pp. 152-186. ISBN 978-1-84542-238-7.

(2) NOTEBOOM, T., The relationship between seaports and the inter-modal hinterland in light of global supply chains, *Research Round Table, Seaport Competition and Hinterland Connections*. Paris, 10-11 April 2008.

(3) BARTOŠEK, A., MAREK, M., The Development of the Future Direction of Containerized Goods in Europe, *52nd Annual Transport Research Forum*, Long Beach, 2011.

(4) SCHÖNEMANN, R., Integrating Railway Services in Supply Chains - The Last Mile of the Transhipment Interface Seaport-Rail, *International Scientific Conference - The Transport of the 21St Century*, Warsaw University Of Technology, Białowieża, 2010.

(5) ČSKD Intrans, Metrans, Polzug, AWT, Samskip, H&S Container Line, Port of Hamburg, Port of Rotterdam, Port of Bremerhave etc. [on-line].

(6) SCHÖNKNECHT, A. *Maritime Containerlogistik.* Springer Heidelberg: Springer-Verlag Berlin, 2009. 145 pg. ISBN 978-3-540-88760-7.

(7) ŠIROKÝ, J., Modal Split and Importace of Transport Infrastructure Into Terminals of Intermodal Transport, *Perner´s Contacts*, Vol. 16, pp. 114-125, 2009.