Twin hub network: an innovative concept to boost competitiveness of intermodal rail transport to the hinterland

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ABSTRACT

This paper presents the concept and first results of a new research and development project called "Intermodal rail freight Twin hub Northwest-Europe" (= Twin hub network). The main idea of this concept is to bundle the container hinterland transport flows of the seaports of Rotterdam and Antwerp (and smaller seaports) in order to increase the size of trainloads, the service frequency and/or the network connectivity, and hence to improve the cost performance and quality of rail hinterland transport. The bundling takes place in a specific hub-and-spoke service network in which the seaports can mutually boost their performance of rail hinterland transport and can enlarge their hinterland service area by rail.

The first results with regard to the identification of promising Twin hub networks demonstrate the conceptual logic: new rail services to the hinterland can be developed by this bundling whereas otherwise the trainloads to/from hinterland regions would be too little to start up a service.

INTRODUCTION

This paper presents the concept and first results of a new research and development project called “Intermodal rail freight Twin hub Northwest-Europe” (= Twin hub network). Its general aim is to increase intermodal rail competitiveness. The main project idea is to bundle the hinterland transport flows of the seaports Rotterdam and Antwerp (and smaller seaports) in order to increase the size of trainloads, the service frequency and/or the network connectivity. Such changes will improve the cost performance and quality of rail hinterland transport. The bundling is to take place by a hub-and-spoke configuration centered on the gravity points of the envisaged flows of Antwerp and Rotterdam. The bundling concept is carried out in a way that acknowledges the existence of seaport competition and takes account of the fact that the cooperating intermodal rail operators are competitors.

The paper describes the concept, features, first results and the structure of the project. The paper’s aim, however, is not simply to disseminate the project work, but to inspire the sector to incorporate some of the features of this project into other innovation initiatives, in line with the expectation for this project, which is: *intermodal performance can be increased substantially by the introduction of innovative train services, also in difficult organizational settings like the cooperation of competitors (seaports, intermodal operators).*

The paper first describes the challenge for intermodal rail development. Then the logic of freight bundling is discussed, which is a major issue for intermodal transport development. Next the concept of the Twin hub network is explained in more detail and the organizational setting and steps to test the viability of the concept in practice are expounded. The paper ends with conclusions.

CHALLENGE

In Europe as well as in many other regions in the world the truck is by far the most dominant mode in freight transport. In the European Union the truck accounts for 44% of all freight (in ton) carried in this region and when the sea mode is excluded its share rises to even more than 75% (*1*). Moreover, over the last decades the share of truck transport has continuously increased.

In view of freight flow projections for total inland transport with the European Union that indicate a growth of almost 50% from 2005 to 2030 (*2*) and the need for more sustainable transport it is clear that alternative modes like rail and barge should increase their role in freight transport. In general intermodal transport is considered as one of the most promising markets for train and barge to regain market share as it combines advantages of barge or train with truck transport. Without doubt volumes transported intermodal by rail and in particular by barge in Europe have increases spectacular over the last two decades. Intermodal rail volume (containers, swap bodies and truck trailers) handled in the European Union in 1996 was estimated at 8 million TEU (*3*), while the volume amounted 16.5 million TEU in the European Union (excluding Sweden and Finland, and including Switzerland, Turkey, Croatia, Serbia and Macedonia) in 2009 (*4*). Intermodal barge transport, which has a much shorter history and smaller land surface that is being served (i.e. The Netherlands, Belgium, France and Germany), recorded a growth of approximately 0.5 million TEU in 1985 to 2 million TEU in 1996 and more than 5 million in 2009 (*5*; *6*). These volumes are impressive, but estimates show that intermodal (rail and barge) transport do not account for more than 5% of the total surface traffic (in tonne-km) of goods in Europe as a whole.

In looking over the intermodal rail industry in Europe, the business is rather concentrated and mainly carried out on a very limited number of corridors. Major corridors include the hinterland of seaports, as about the half of the intermodal rail volume is hinterland transport (consisting of maritime containers), while the other half consists of continental transport, i.e. rail services for goods that have their origin and destination at the European continent (mainly consisting of swap bodies and truck trailers).

Development of intermodal rail transport to the hinterland is of major interest both for intermodal rail operators (because of its growth potential due to growth in deep sea container transport) as well as for port authorities.
Increasing container throughput in the ports also leads to increasing transport volumes in their hinterlands and this is putting pressure on the capacity and quality of the hinterland transport system. The development of intermodal hinterland transport (rail and barge), enabling large-scale transport services, has gained importance to keep the port accessible by shifting cargo away from the congested roads to the railways and waterways, as well as to anticipate to and comply with environmental regulations (i.e. emission norms).

The long-term ambition of the port authority Rotterdam is to realize a modal split of 45% barge, 20% rail and 35% truck transport for its new container terminal area (Maasvlakte 2) in 2033 (*7*). In the concession contracts of new container terminal operators that will be established at Maasvlakte 2 the operators must meet the criterion that at least 65% of their hinterland transport is carried out intermodal (barge and rail). When the terminal operators do meet these targets they will be fined. On the other hand, the port authority should create facilities (i.e. reservation of space to build rail terminals) to enable such a modal split. Its current modal split for the whole port is 56% truck, 33% barge and 11% train. The aim is to about to double the share of rail transport, but in view of this modal shift goals and the projections of container throughput in the port the rail volume could more than triple from its present 1 million TEU to 3.6 million in 2033. How to handle this flow is a major challenge.

Until now rail transport has played a modest role in container hinterland traffic for several reasons, including a lack of rail capacity. The opening of a dedicated freight rail line (the Betuweline) in 2007, connecting the port of Rotterdam with

Germany, has significantly increased the rail capacity. Basically this line could absorb the expected growth of rail containers, but problems are envisaged with the capacity of rail infrastructure in the port (i.e. railway yards) and also at the rail terminals. Today these problems are already observable, since trains have a long dwell time in the port and have difficulties to keep their schedule of services. A sample at Rail Service Centre Rotterdam indicated that about 60% of the trains are delayed (*8*). Different procedures required to run a train (e.g. the need to change locomotives at yards) and the type of train services (i.e. 1/3 of the trains run according the shuttle principle, while 2/3 of the trains have to visit 2 or 3 terminals in the port) add to these problems.

A great concern is the large number of yards that would be required if the current processes to run and handle trains would remain the same in future. In other words, it is not only a matter of growing volumes that causes capacity problems. An increasing number of actors involved in rail operations in the port also contributes to less efficient use of the rail infrastructure, because it leads to co-ordination problems. From 1995 to 2007 the number of rail operators increased from 6 to 21 operators. In 1995 just one train operator was responsible for locomotive haulage, while in 2007 10 operators offered these services. In the same period the number of rail terminals increased from 3 to 8 terminals (*8*). Currently the port counts 12 terminals where containers can be handled and the completion of the Maasvlakte 2 will add another 4 terminals. The increasing number of terminals and operators may lead to fragmented container flows and hence more trains to run to the hinterland or more trains to visit multiple terminals in the port to bundle flows. Both options put a large claim on scarce infrastructure.

The port of Antwerp has similar goals to increase the share of rail in container hinterland transport. In Antwerp the target for the modal split in 2020 is 40% barge, 40% truck and 20% rail (*9*). Just like the port of Rotterdam this port is suffering from the fact that in the port many terminals need to be served, which hinders the efficiency of processes of handling trains in the port.

In addition, other (smaller) container ports in the North sea region, like Zeebrugge (in Belgium), are also increasingly focused on developing and extending intermodal transport services. However, these smaller ports are faced with the fact that due to their smaller container throughput, container freight flows tend to be rather small and dispersed to hinterland regions, which makes it difficult to establish direct train services to these regions.

To realize a modal shift from truck to train will in general require improvements in the cost performance and quality of intermodal transport. According to the analysis of the research project ‘Intermodal quality’ its performance in Europe is still poor in terms of network connectivity and service frequency, except for transport in some large flow corridors, from and to some large nodes, and in some well-organized regions (*10*). Rail transport is typically chosen for its low costs (e.g. *11*; *12*), but apparently they often are not low enough, since the service revenues do not cover the operational costs, as has been the case for instance in companies in Germany (DB Cargo according to *13*), Italy (Trenitalia according to *14*), France (SNCF Fret according to *15*; CNC according to *16*), the UK (Freightliner according to *17*), Railion Netherlands up to 2005 (*18*) and Inter Ferry Boats in the NARCON network in Belgium (Van Petegem according to *19*).

These issues are in particular manifest in transport relations in which transport volumes are still rather small, since basically substantial freight volumes are needed to run a train profitable from A to B at an acceptable frequency level, as rail transport is typically a volume business. As a result the truck is in many situations a more appropriate mode, in particular in cases in which the freight volumes are small and destinations are dispersed.

Given this inherent disadvantage of rail to truck, a major strategy to deal with small flows and expand intermodal rail transport is pursuing network innovations (*20*). The Twin hub project believes it can contribute to strengthen intermodal transport in this regard. Also, planning and operational mistakes of the past should be avoided. Important principles from this angle are: avoid too optimistic flow projections, organize large trainloads by appropriate bundling, organize productive train roundtrips, bundle by load unit transshipment or wagon group exchange and avoid single wagon exchange. With regard to door-to-door services: provide a good logistic match, namely an acceptable level of service, acceptable transport speed and desirable departure and arrival day times of trains. Aiming for high performance services firstly requires designing innovative efficient network operations and on the longer term also incorporating innovative technical concepts. The best high-performance is one that also reduces operational costs. The Twin hub project is designed on the basis of these principles.

BUNDLING BASICS

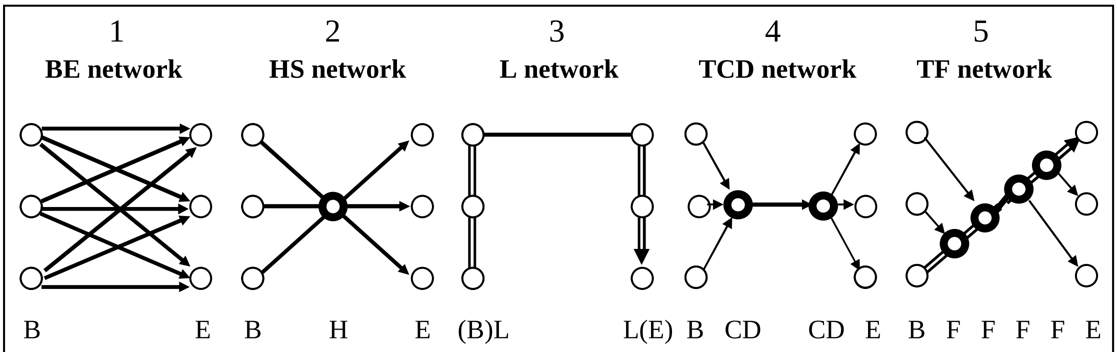
Bundling types

Bundling is the process of organizing large trainloads for flows, which are too small to fill a train on the required frequency level. One can distinguish bundling of freight regarding different directions, different freight categories and in time. The first, the most important type, is about letting flows belonging to different transport relations move in same trains (vehicles) during a part of their journey (for further explanations see *20* and *21*). The second addresses the transport of different goods or shipment types in the same vehicle, like bundling intermodal and non-intermodal flows. Bundling in time boils down to frequency reduction. Trains might even only depart when a certain trainload has been built up.

Types of bundling networks

There are alternative concepts to bundle the flows. We distinguish five basic types. If flows have a sufficient size, they should be serviced by direct trains (= BE or direct network; Figure 1-1), as these have the shortest routes, no intermediate exchange and only trunk rail operations. In combination with a full trainload direct networks generate the lowest costs of all bundling alternatives. For smaller flows, complex bundling is to be envisaged, like bundling in a hub-and-spoke network (Figure 1-2), in a line network (Figure 1-3) or other types of networks (Figures 1-4 and 1-5). Which type of bundling is appropriate is strongly determined by the spatial pattern of freight flows (i.e. the volumes between each pair of shippers and consignees) and the location of terminals. One should be aware that the transport volume at the begin terminal is usually also the result of a bundling process, i.e. trucks that have collected load units in the region around the terminal. These truck hauls are relatively expensive operations, in particular at larger distances. So if the distance between shipper and terminal is rather large trucking only between shipper and consignee may be more cost-efficient than an intermodal operation. This issue is evidently also relevant in the distribution of load units from the end terminal to consignees.

FIGURE 1 The basic bundling types



LEGEND
→ = trunk train service (BE network and HS network)
or trunk part of a trunk train service (L network and TF network)
⇒ = local part of a trunk train service (L network and TF network)
→ = local train service (TCD network and TF network)
○ = BE terminal (in L network also L terminal)
◉ = intermediate unimodal (e.g. rail-rail) exchange node

BE network = begin-and-end network (or direct network)
HS network = hub-and-spoke network
L network = line network
TCD network = trunk-collection-and-distribution network (or fork network)
TF network = trunk-feeder network

B = begin terminal E = end terminal H = hub node L = line terminal
CD = collection-and-distribution node F = feeder node

*
The figure does not show pre- and post-haulage.

Train networks are "uni-directional and separated" ones.

Source: *20*

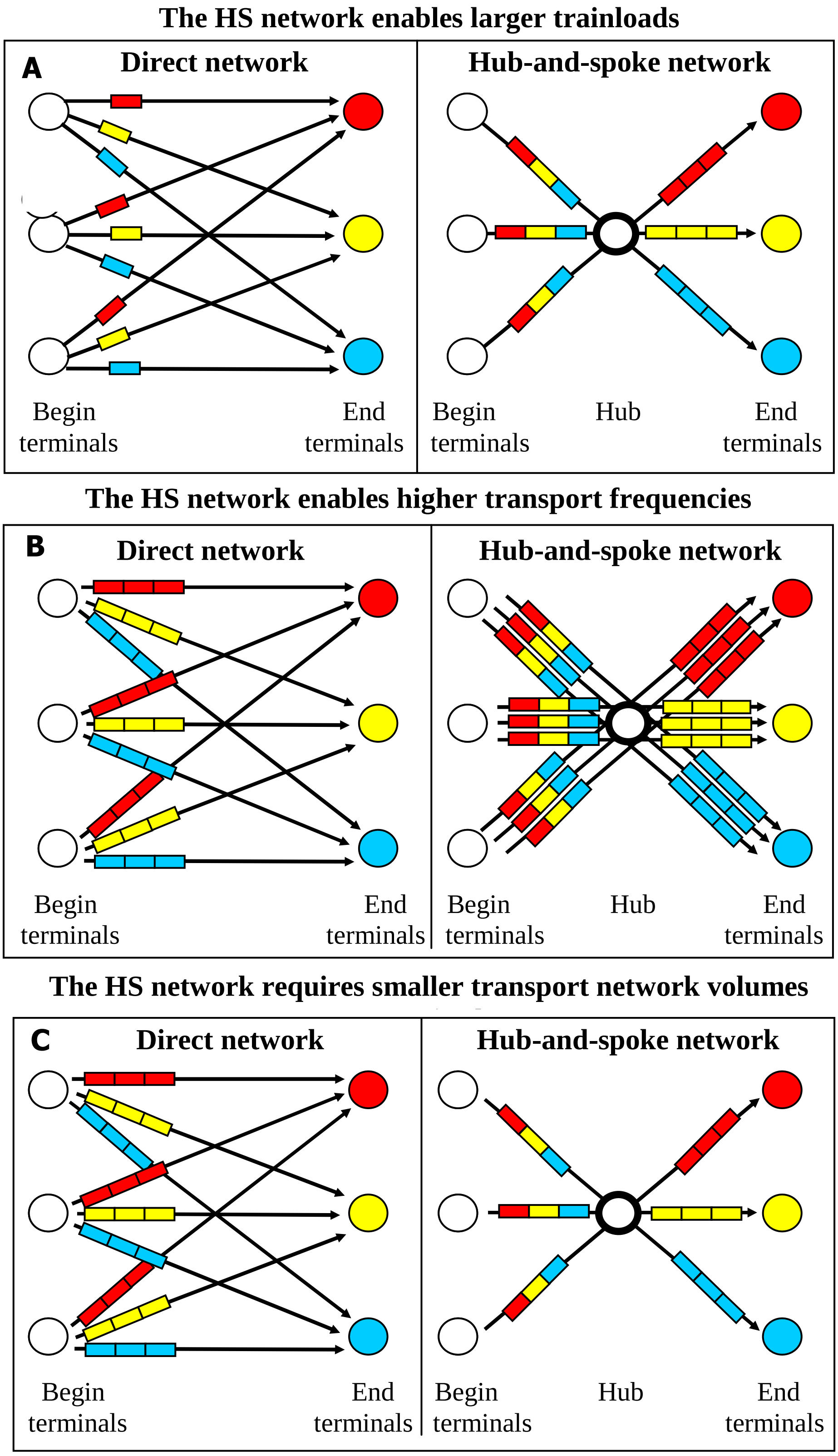
Performances of the Hub and Spoke (HS) bundling network

In the HS-network the number of train routes is smaller than in a direct network (see Figure 2: 9 routes in a direct network and 3 routes in a HS network). Consequently, this enables to provide larger trainloads (Figure 2-A: each shaded little block represents a trainload; in a HS network the train carries 3 blocks and hence has a larger trainload) or higher frequencies (Figure 2-B: each arrow represents one service). Alternatively, the HS-network is able to deal more efficiently with smaller network transport volumes. The total transport volume in the network is the product of the number of routes, the frequency of services along these routes and the number of load units (containers) that are carried in each service. As Figure 2-C shows, with 3 begin terminals and 3 end terminals only one-third of the total network transport volume of a direct network (i.e. 27/3) is needed in a HS network to run trains with large trainloads.

In addition, it is clear that HS networks will provide a higher network connectivity, i.e. for a given number of transport services more end terminals can be served from each begin terminal (*20*; *21*). Or in other words, less train routes are needed to offer the same connectivity as in a direct network: 3 routes in a HS-network versus 9 routes in a direct network (see Figure 2).

Of course complex bundling also has disadvantages such as longer train routes, more intermediate node exchange and/or local train networks. In hub-and-spoke networks the detours are limited (for comparison of detours of alternative bundling networks see *22*), and each load unit network-averagely has between 0.5 and almost 1 additional exchange at the hub, dependent on the number of spokes in the network. A very important characteristic of hub-and-spoke bundling is that there are no local rail network parts, contrary to the three other complex bundling networks (as shown in Figure 1). All hub-and-spoke trains run as trunk trains, in other words principally have full trainloads, generating low train costs per unit of freight (e.g. ton or load unit).

FIGURE 2 Three potential benefits of hub-and-spoke networks compared to direct networks



Source: *23*

Types of exchange operations in the hub

For the exchange of load units between trains at hubs there are three types of operations:

- Exchanging single wagons between trains (along with their load units) by means of shunting. This process requires a gravity shunting yard and seems to be relatively costly (on the basis of *24*) and certainly is very time consuming (*25*);
- Exchanging wagon groups between trains (along with their load units) by means of shunting. This process can take place at a gravity or a flat shunting yard. generates competitive exchange costs (on the basis of *26*) and is relatively fast (study of timetables of *27*). But it is only suitable for the wagon group market. In other words, the required flow sizes at intermediate exchange nodes are larger (having the size of a wagon group) than for the single wagons;
- Transhipping load units at a terminal. This in principle leads to competitive exchange costs in terms of costs and time and is suitable for all intermodal markets (e.g. directional groups, single load units per direction). However, within this exchange type there are two options, which lead to quite different results. One is the development of true hub terminals, designed for substantial amounts of rail-rail transshipment. If the rail-rail exchange volume is larger, the terminal will need to be a true hub terminal. Its special features, distinguishing it from a normal rail-road terminal are a different layout (more tracks beneath a crane) and the presence of a terminal internal sorting and transport system, which reduces the amount of crane work. The second option is the development of what currently is often called “gateway terminals”. They belong to “gateway networks”. In this case the rail-rail exchange takes place at begin-and-end terminals, which are actually designed for and mainly have rail-road transshipment. Due to the typical arrival and departure times of trains at European inland terminals (evening departures, late night arrivals), load units that are transferred between trains have long dwell times at the gateway terminal. In addition, the gateway network most often essentially represents the interconnection of direct train services. It does not generate scale economies due to the reduction of train routes through the network. There is no reduction. For such reasons the International of Railways (UIC) advises not to implement gateway networks, unless the transport distance is rather large (*28*).

Clearly the hub exchange at true hub terminals is most competitive in terms of scale effects, dwell times and market response (suitable also for single load units per direction). Wagon group networks in the 1990s used to be the backbone of European intermodal rail transport (*28*), but are clearly losing market share. The decline of the market share of the old national railway companies and their rail families may be a reason for such. Reflecting on combinations of exchange types, like exchanging wagon groups and transshipping load units of the same train, is – for the size of trainloads in Europe – hardly a feasible option. In countries with much larger trainloads, like USA or Australia, the situation may differ.

Despite the benefits of true hub terminals, their market penetration is extremely low. After the first of its type being built in the 1990s (Mainhub terminal of Interferryboats in Antwerp), two other ones are currently on their way, namely Limmattal (in Switzerland) (*29*) and Hannover Lehrte (in Germany) (*30*). While the Mainhub in Antwerp was innovative only by its concept and layout, the Lehrte hub will also have a high performance sorting and transport system. In addition, many operations in Lehrte will be robotized.

In the meantime gateway networks have become quite popular. Rail operators like them because they can use their own terminals for such operations. Not the benefits from operational characteristics, but the easiest implementation path seems to be leading for such development.

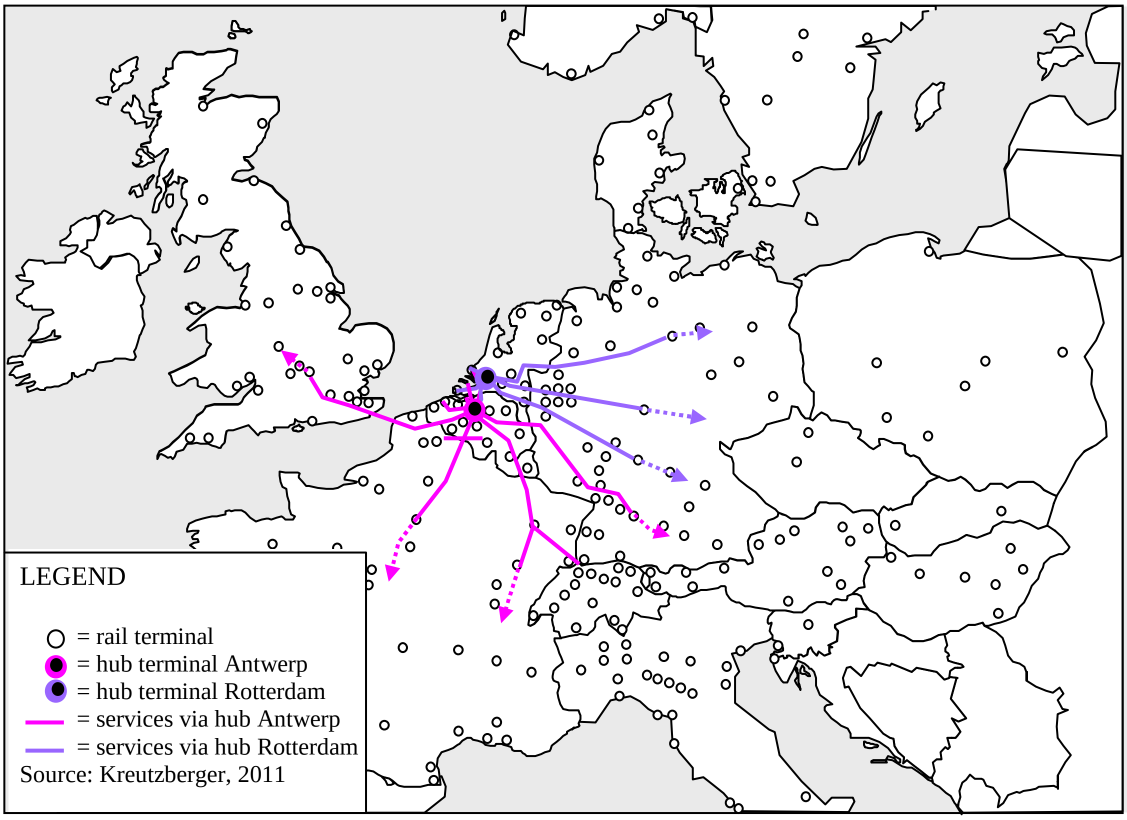
There are many reasons for the low penetrations speed of true hub terminals. The reasons are not the subject of this paper. But at the end the penetration process might very much resemble that of the first sheep crossing a hill, comparable with ECT's deep sea container terminal robotization, which – almost 20 years after its introduction in Rotterdam – is now becoming a mainstream approach throughout seaports in European countries with a relative high standard of living, in other words countries generating high labor costs.

THE TWIN HUB CONCEPT

The network idea

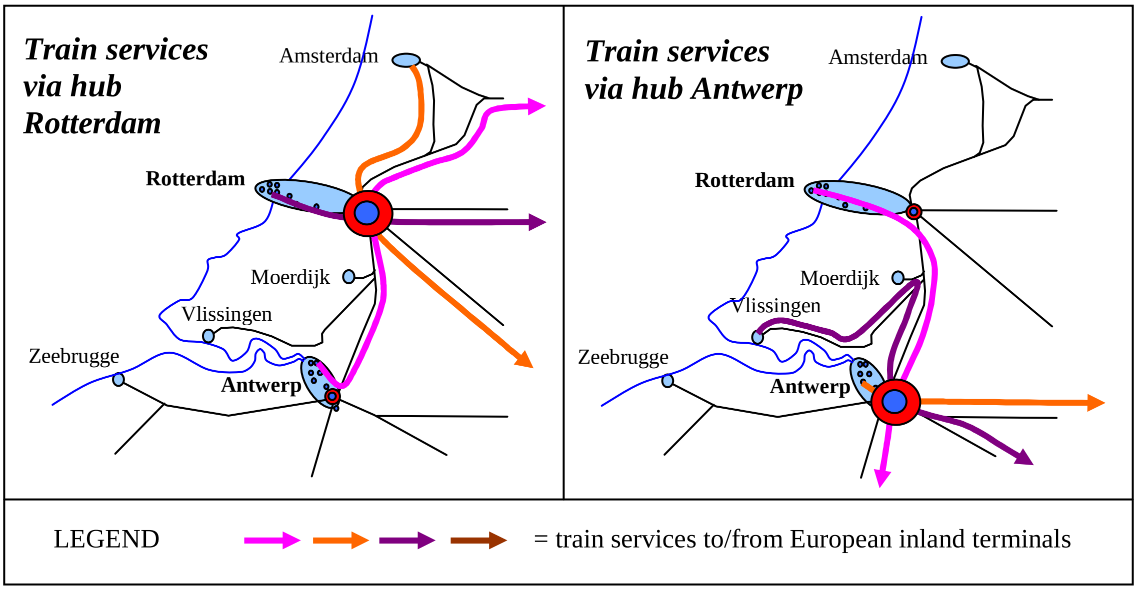
The Twin hub network connects the two large seaports of Rotterdam and Antwerp and smaller seaports in their vicinity on the one side with inland terminals in European regions, for instance in France/Spain, Germany/Poland, and the UK (Figure 3) on the other side. Each train in the Twin hub network runs between a maritime rail terminal and an inland rail terminal. On its way it visits the hub Antwerp or Rotterdam (Figures 3 and 4), where it exchanges load units with other Twin hub trains.

FIGURE 3 The Twin hub network (examples of train services on the longer term)



The device is: let Dutch load units go with Antwerp trains wherever these have or could have a strong market position in the hinterland, and let Belgian load units lift on Rotterdam trains wherever these have or could have a strong market position in the hinterland. Finally, let flows between an inland terminal and the "west" seaports (the range Amsterdam – Dunkirk) ride in joint trains instead of separate ones to each seaport. Each load unit only visits one hub, and some of the load units change trains at the hub. There are only trunk trains in the network. Acknowledging seaport competition, the focus of this cooperation is that of complementary corridors, i.e. Rotterdam Twin hub train services are being more oriented to the northeast, Antwerp ones more to the southwest.

FIGURE 4 Zooming into the Rotterdam and Antwerp regions of the Twin hub network



Expected performance improvements

The expected performance improvements are easy to explain, assuming the reference to be each large seaport (Rotterdam or Antwerp) having a separate hub-and-spoke network. The hub-and-spoke networks are not interconnected, and they will stay so in the Twin hub configuration. The Twin hub network essentially enlarges the service area of each hub, adding flows (and spokes) to the network. The Rotterdam hub area is extended to other seaports in the Netherlands and in particular in Belgium, the Antwerp hub area to seaports in the Netherlands.

By Twin hub bundling the following performance improvements are expected to be achievable, namely:

1. lower train costs per load unit due to larger trainloads;
2. lower pre- and post-haulage costs due to an increased network connectivity. In addition the regional accessibility becomes more robust as more regions are served not only by road, but also by rail;
3. lower generalized transport costs due to a higher level of service. These costs are lower than in separated hub-and-spoke networks (= hub-and-spoke networks per seaport or per country), and lower than for direct train services.

THE TWIN HUB PROJECT

The project consists of four work packages (WP). WP1 is to identify promising Twin hub service networks for the pilot and on the long term. The work starts with the establishment of a European Origin/Destination-matrix of freight flows, the design of bundling networks and modal shift analytical work.

In the center of WP2 and of the entire project is a pilot to demonstrate the concept on a small scale: three pilot trains run between a rail terminal in a seaport and an inland terminal, in between visiting a rail hub (Rotterdam or Antwerp). The three pilot trains visit the hub during the same time in order to have much direct train-to-train exchange. The hub exchange is most likely to be terminal transshipment, but could also be wagon group exchange, dependent on the operational philosophy of the involved operators. The pilot is carried out by three firms, which cooperate in the project, but outside of the project potentially are competitors. The preparation of the pilot includes the writing a joint business plan. The pilot will be monitored. Another action within WP2 is to build an innovative booking system to simplify and effectuate the pilot operations.

The subject of WP3 is long-term infrastructure needed to carry out Twin hub operations efficiently on a larger scale than the pilot. The work packages focuses on the infrastructure in the hub regions. The aim is to interest key decision-makers in the field of infrastructure and spatial planning to advocate such infrastructure. For Rotterdam the main subject is hub development. For Antwerp most likely the main topic is smoothening the links from and to the hub.

In WP4 the societal benefits will be analyzed, in particular the impact on the intermodal sector, transport sustainability and regional development. Also, some recommendations will be formulated for (European) transport policies.

The project partners are three rail operators, two seaport authorities, four universities and three consultants. In addition, the project has an Advisory board, its members being stakeholders, knowledge providers or second opinion providers (like regions, actors in the field of infrastructure, intermodal specialists).

STEPS TO IDENTIFY PROMISING TWIN HUB NETWORKS

Approach

The identification work takes place along three parallel actions. Firstly, the project is developing a bundling tool to assign flows to train services in a way that responds to the way of network design in practice and minimizes costs rather by maximization of vehicle loads than by minimization of distances. Secondly, a tool comparing door-to-door transport prices of competing modes is being extended to the European level. Thirdly, there is a hand approach deriving promising bundling options directly from the O/D-matrix without the use of costs of prices. The feasibility of the identified networks is then controlled by cost calculations. The assumption in this approach is that large trainloads are already a good first indicator for promising networks. The approach does not optimize, but is useful for cherry picking, exactly what is at stake to choose transport relations for the pilot. The rail operators in the project like this approach, as it hardly has any black boxes and is easy to understand. The first results presented in the following section refer to this approach. The tools support network identification on a larger scale, like finding relevant Twin hub networks for the medium and long term.

Increasing trainloads without increasing network connectivity

Which performance improvement is achievable depends on the flow sizes and bundling choices. Table 1 shows the size of trainloads between the envisaged seaports and a selection of inland terminals, given a certain frequency level, in this case three train departures per week and direction. Each cell in the matrix of Table 1 represents a directional flow between a begin terminal and an end terminal. Different cells of the matrix can be combined to larger flows. The choice of cell combinations represents a bundling choice. For instance, combining cells to the same hub could represent the bundling of flows between a begin terminal and the hub, combining cells in a column could represent the bundling of flows between the hub and an end terminal.

The finding of beneficial stand-alone Twin hub networks can take place in such a spreadsheet approach (as described by *31*). To identify promising Twin hub networks on a large scale (e.g. for the entire matrix) a bundling tool is required. In the Twin hub project such a tool is currently being developed.

The flows in the table are fictive (although not unrealistic) in order to demonstrate the magnitude of benefits more easily.

The first type of performance improvement could be achieved to inland terminal 1 (first column in Table 1). The biggest flow to inland terminal 1 coming from Rotterdam rail terminal B3 has a size of 0.7 trainloads. This flow is, according to practical experience, on the borderline of what is needed to be sent by a direct train. The trainload size could be enlarged by combining this flow with other ones. There are different options including:

- line bundling, comparable to current operations: The train is partly loaded at one rail terminal in the port and then filled up at a second rail terminal in the port. In the matrix this is represented by combining the flows B3->E1 and B1->E1, leading to a total trainload of (0.7 + 0.1 =) 0.8. The cost reduction of such increase is calculated using a (component based) rail cost model. This calculates the rail costs per load unit using distance, operational time, periodical roundtrip time of locomotives and wagons, and driver’s time as input. The increase of trainload roughly comes down to a reduction of train costs of about 13%. As line networks have no additional exchange in comparison to direct networks, this cost reduction does not become less by node costs;

- hub-and-spoke bundling of Rotterdam flows (combining the flows B3->E1, B1->E1 and B5->E1) leads to (0.7 + 0.1 + 0.1 =) 0.9 trainloads between the hub and the inland terminal. If a comparable trainload is also organized between the port terminal and the hub, a reduction of train costs of 22% can be achieved. For such flow combination, say the combination of more than two flows, line bundling hardly is an option. The additional hub-exchange for some of the load units limits the cost reduction by almost 3%-points providing a net cost-reduction of about 19%;
- line bundling in the hinterland region. The efficiency condition is (unless the first inland terminal also has flows entering the network in the direction of the second inland terminal) that the accessed inland terminals are located in another's vicinity. In other words, the route between the two inland terminals should either be short or have large trainloads. The presence of such a spatial situation is indicated in Table 1 by the color of the columns. Neighbored columns of the same color (yellow or white) are located in the same inland region. The flow B3->E1 (= 0.7 trainloads) can then be bundled with the flow B3->E2 (= 0.2 trainloads), cumulating in a total trainload of 0.9 trainloads for most of the journey and a cost reduction comparable with the first line example;
- hub-and-spoke bundling integrating the flows of other seaports. The most interesting one in this case is the flow from B8->E1 from Antwerp (= 0.3 trainloads). Together with the flow B3->E1 from Rotterdam (0.7 trainloads) it leads to a total trainload of 1 and a reduction of train costs of 30% before hub costs and 26% after hub costs (the hub exchange refers to a larger amount of load units and therefore absorbs 4%-points of the train savings). The detour of hub-networks in comparison to direct rail networks is relative small compared to the detours of other complex bundling networks (detours have been analyzed extensively in Kreutzberger, 2008a). For average and long distances the detours are not likely to change the cost reductions significantly. For short train distances (like to Duisburg = 250 km) the cost effects of detours may be substantial and should be checked.

In all of these bundling options only flows with a comparable distance are taken into consideration: "Day A/B relations" indicates that the trains serving these flows can all arrive at the end terminal the day after departure. Bundling day A/B relations with day A/C relations implies that the trains in the Twin hub batch have different roundtrip times. The latter is not impossible to organize, but makes the transport planning more complicated.

TABLE 1 The size of flows between seaports (= begin terminals in this matrix) and inland terminals (= end terminals in this matrix), in number of trainloads *

			Day A / B relations					
		End ->	Terminal E1	Terminal E2	Terminal E3	Terminal E4	Terminal E21	Terminal E22
	Begin ↓							
Seaport Rotterdam	Terminal	B1	0.1	0.4	0.5	0.4	0.8	0.8
	Terminal	B2	0.0	0.0	0.2	0.0	0.0	0.0
	Terminal	B3	0.7	0.2	0.1	0.2	0.2	0.0
	Terminal	B4	0.0	0.0	0.0	0.0	0.0	0.0
	Terminal	B5	0.1	0.0	0.1	0.0	0.0	0.0
Seaport Antwerp	Terminal/Cay	B6	0.0	0.5	0.4	0.5	0.8	0.9
	Terminal/Cay	B7	0.5	0.1	0.0	0.4	0.1	0.2
	Terminal/Cay	B8	0.3	0.1	0.1	0.1	0.0	0.1
	Terminal/Cay	B9	0.0	0.0	0.0	0.0	0.0	0.0
	Terminal/Cay	B10	0.2	0.0	0.1	0.0	0.0	0.0
Other seaports	Amsterdam	B11	0.0	0.1	0.0	0.0	0.0	0.1
	Moerdijk	B12	0.1	0.0	0.1	0.0	0.1	0.0
	Vlissingen	B13	0.1	0.0	0.0	0.1	0.1	0.1
	Gent	B14	0.0	0.0	0.0	0.0	0.0	0.0
	Zeebrugge	B15	0.1	0.0	0.1	0.0	0.0	0.0
	TOTAL		2.2	1.4	1.7	1.7	1.3	2.2

* The flows in this table are fictive ones. Pink cell = reference flow.
"Day A/B" is to say that the train arrives at the end terminal on the day after departure.

Increasing the size of trainloads in amounts suitable to increase network connectivity

The largest flows to the inland terminals E2, E3 or E4 (Table 1) have a size of 0.5 trainloads, coming from the rail terminals B1 or B6. These flows can impossibly provide feasible train services and will go by other modes than rail unless the flows of Rotterdam and Antwerp are bundled. The result is a typical Twin hub operation, in this case not simply enlarging the size of trainloads (from 0.5 to 0.9 implying a reduction of train costs of 62% before and 57% after hub costs), but – while doing so – also trespassing the feasibility frontier. The result is that inland terminals can be accessed which otherwise could not be served by rail, or which otherwise would generate high pre- and post-haulage costs as the destination region is located on quite some distance from other rail terminals. The costs of long pre- and post-haulage distances can have a very significant share in the total cost of the intermodal chain, and in case of short rail distances even an impediment to use intermodal transport.

The higher network connectivity has several derived regional economic benefits. Firstly, it will make the accessibility of hinterland regions more robust, since establishing rail services makes regions less dependent on truck transport. Secondly, it may contribute to regional-economic development, as it increases territorial cohesion or decreases regional disparities. The latter because hinterland regions that generate small freight flows may reduce their transport costs, as they can benefit from economies of scale and scope in rail transport as a result of bundling the flows in the seaport regions. Both these benefits are the subject of later research activities in the Twin hub project (see below).

Increasing the level of service

As table 1 shows, the flows to inland terminals E21 and E22 from Rotterdam B1 and Antwerp B6 are large ones having sizes of 0.8 to 0.9 trainloads (Table 1). They could be sent by a direct train, however, only three times a week. An important alternative is to bundle these large flows (0.8 + 0.8 trainloads from Rotterdam B1 and Antwerp B6 to terminal E21, and 0.8 + 0.9 trainloads from the same begin terminals to terminal E22). In this way the trainload is not increased, but the service frequency more or less doubles to 6 departures a week.

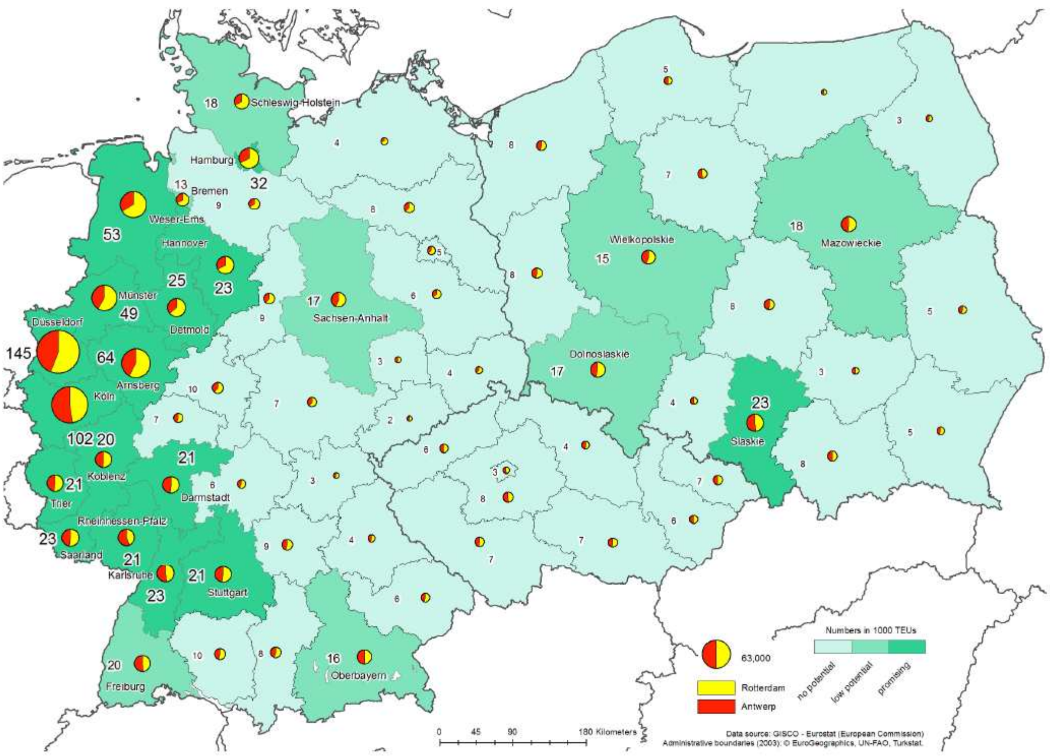
Studies about the valuation of service frequency by shippers are not ultimately conclusive. The European Council for Applied Sciences and Engineering (*32*) concludes that frequency is one of the factors impeding intermodal growth: "Less-than-daily services are not attractive, and many carriers would prefer the option of 2-3 services a day". On the other hand Notteboom (*33*) observes that "The marginal utility to shippers of an additional departure sharply declines once a daily service is offered". Moreover, there are large differences in the valuation of transport quality including service frequency between the continental and the maritime market of intermodal rail transport (e.g. *34*).

In European transport practice service network design often seems to begin with general notions of frequency levels and trainload size to be achieved, 3 departures per week being the minimal level and 5 departures a truly satisfying service level.

FIRST RESULTS

Switching from fictive to real flow data, Figure 5 shows the first results of a freight flow data analysis. It illustrates the size of bundled flows of containers transported by truck between Antwerp and Rotterdam per hinterland region. These containers by truck are the flows to be captured by intermodal transport. The regions that have sufficient flows for Twin hub services are highlighted. "Sufficient" means that trains can run at least break-even (defined as 80% loading degree of a train of 600 meters length) and the frequency of services is acceptable to shippers (i.e. three times a week per direction). Based on these criteria a sufficient volume means 20,000 TEU on annual base. The map - just as comparable maps on other parts of the continent - do not only show promising regions (regions where the joint volume of flows related to Antwerp and Rotterdam exceeds 20,000 TEU), but also that these are only promising by the grace of combining the flows of Antwerp and Rotterdam. For instance, the volume to the Polish region Slaskie (23,000 TEU) is very illustrative, as about half of this volume (11,000 TEU) consists of inbound and outbound flows to Rotterdam and the other 12,000 TEU represents flows to and from Antwerp. Running trains from Antwerp or Rotterdam only would lead to too small trainloads (about 0.5 trainloads) instead of sufficient ones (above 0.8 trainloads). The volume of 0.5 trainloads of Rotterdam and Antwerp are already the result of bundling the flows from or to different rail terminals of the same seaport, for instance by bundling them in separated hub-and-spoke network (e.g. in Antwerp) or in a line network (as is more likely to be the case for Rotterdam). It is the Twin hub network, which increases the size of trainloads and network connectivity.

FIGURE 5 Size of container flows by truck (in 1,000 TEU) between the seaports of Rotterdam and Antwerp and hinterland regions (in Germany, Tsjech Republic and Poland), 2010



Source: Konings, 2012, in the framework of WP 1 of Twin hub network. The map is produced by Delft University of Technology (OTB) based on data from the European ETIS project, that are processed by Pantheia (NEA) and analysed by Delft University of Technology (OTB) (*35*).

It should be stressed that this analysis of flows only provides an indication of potential promising hinterland regions to which train services can be developed. Which part of the road containers can really be captured by rail obviously depends on the performances of the train services in a Twin hub network compared to truck transport. Decisive factors for the competitiveness of the Twin hub train services are the transport distance of the services, the characteristics of the circulation of trains in these services (e.g. slack time in their schedule should be limited), the time and cost-efficient exchange of container between the trains in the hub, but also possibilities to have cost-efficient drayage operations in the intermodal service. These analyses are currently being carried out by TU Delft and will be finalized in the first quarter of 2013.

CONCLUSIONS

Innovative networks designed to improve the performances of sustainable transport modes such as intermodal rail transport, are highly relevant, because only if the network operations of sustainable modes are competitive to road transport a shift from road transport to sustainable modes can be realized. Moreover, if new rail services can be developed the accessibility of regions is enhanced and their accessibility becomes more robust, since shippers can then choose between more than one mode, i.e. truck and train.

The Twin hub network is a bundling concept for intermodal rail freight flows that is aimed at improving the competitiveness of intermodal rail transport to the hinterland of seaports and hence also aimed at extending the market share of rail in the hinterland. The most innovative part of this concept is that it involves a hub-and-spoke network that is set up in a way that seaports can mutually boost their performance of rail hinterland transport. Its logic is to let more flows that due to their restricted size are not capable for direct rail transport benefit from transport scale in terms of larger trainloads, higher service frequencies and a higher network connectivity than would be possible by separated hub-and-spoke networks, let stand direct train services. By bundling the intermodal rail flows from and to Rotterdam and Antwerp and eventually a number of smaller seaports efficiently, more flows can go by rail and more inlands terminals and smaller rail terminals in the seaports can be accessed by rail. This paper outlines the challenge, describes the Twin hub concept being a relevant response to the challenge, and indicates – by presenting first research result – promising regions for the project pilot. The regions identified demonstrate the potential meaning of the Twin hub concept in practice, for instance by enabling to serve numerous new inland terminals, which Rotterdam or Antwerp, let stand smaller seaports, could not serve.

If the project proves that such perception works in practice the concept and this type of cooperation can be extended to other regions including – as independent initiatives of course – seaports on other continents.

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