COMPETITIVE AND SUSTAINABLE GROWTH (GROWTH) PROGRAMME

INTERMODAL TRANSHIPMENT INTERFACES

Working Paper

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1 Introduction

This working paper describes the results of the intermodal transshipment interfaces comparison. Aim of this working paper is to provide a short analysis of the different current and future intermodal transshipment interfaces and apart from this to show possibilities and conditions for an efficient integration of different transshipment interfaces into the inland waterborne logistics and multi-modal transport chains.

The working paper is focused on existing or planned transshipment technology and a number of innovations in transshipment such as:

- Quay-side technologies
    - Barge Express (BEX)
    - Rollerbarge
    - Equipment to Equipment Conveyor
    - Automatic Stacking Cranes
    - Container Gantry Crane / Ship to Shore Crane (trimodal)
    - Reach Stacker
- On-Board and Navigation Technologies
    - RoRo Barge Transshipment
    - Shwople barge
    - Self (Un) Loading Ships
    - Floating Container Terminals
    - River-Sea Barges
    - Riversnake

2 Current Situation

The intermodal transport in Europe is a fast growing part of the transport market. The transport of containers and swap bodies plays an important role in multi-modal transport chains. In container/swap body transport chains a large number of participants take part. The response to this situation presents a large range of strategies. Some of these strategies include transshipment interfaces as a part of the whole concept. The following paragraphs give a very short overview of innovative and present transshipment interfaces and strategies.

2.1 Quay-side technologies

2.1.1 Status: Operational

2.1.1.1 Container Gantry Crane/Ship to Shore Crane (trimodal)

Gantry cranes are widely used in container inland terminals. These cranes are very flexibly in operation. Most of them can be used for the handling either of dry bulk, or general cargo or containers.

The span of the gantry cranes are normally over the waterway (berth), the storage area, the area of road and rail loading. These cranes are so flexible in use that it is possible to take one crane (one type of crane with several attachments, i.e. spreader or gripper) per terminal taking over the handling of all modes.

Technical data (example) of container gantry crane / Ship to Shore crane [1] (trimodal):

Capacity	35 tons
Outreach (riverside)	35 m
Lift height	17 m
Trolley speed	150 m/min
Crane speed	100 m/min

Realisation of gantry crane: operational

[1] Ohse, P.; Größte Containerbrücke in Köln in Betrieb genommen; in: Zeitschrift für Binnenschiffahrt, Nr. 01 Januar 2001; page 34.

Source: http://www.kranbau-eberswalde.de/english/ke.htm

Fig. 1 Gantry Crane

2.1.1.2 Reach Stacker

Reach stackers are widely used in container terminals. Reach stackers are often used for the storage of containers and for the transshipment to road and rail. Reach stackers are very flexible in operation. Some special reach stackers can be used for the loading and discharging of inland cargo vessels.

Technical data of Reach Stacker SC 4545 TA [2]

Maximum lifting capacity (barge handling)

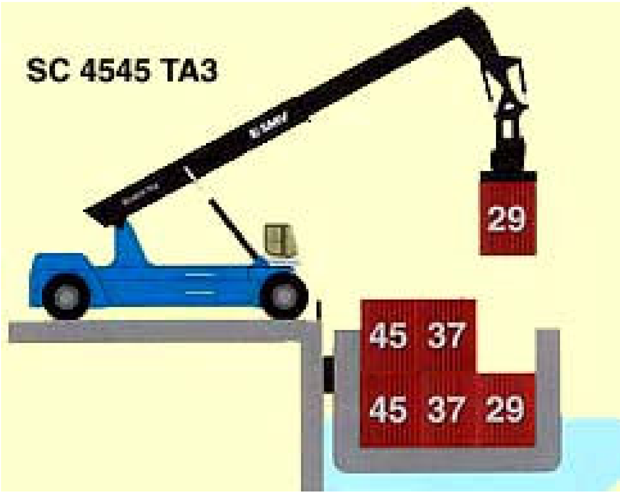
1 first row	45 tons
2 second row	37 tons
3 third row	29 tons

Maximum stacking capacity (terminal operation)

1 first row	2 * 9´6´´ (45 tons)
2 second row	2 * 9´6´´ (45 tons)
3 third row	3 * 9´6´´ (35 tons)

Realisation of Reach Stacker: operational

[2] SMV LIFTTRUCKS AB, Reachstacker SC 4545 TA



Source: http://www.smvlifttrucks.se/

Fig. 2 Reach Stacker

Source: http://www.kalmarind.com/

Fig. 3 Reach Stacker

2.1.1.3 Geographical distribution of ship-to-shore cranes and reach stackers

The following table presents a brief indication of the geographical distribution of the two most common transshipment equipment types in ports: ship-to-shore cranes (gantry and mobile cranes) and reach stackers.

port	sts-crane	reach-stacker	RoRo ramp	Yard trucks / chassis	other facilities
Cologne	5 (40-45t)	6 (16-45t)			
Deggendorf	2 (25-35t)				
Duisburg	3 (35t, 50t)	8 (16-41t)	1	1	Yard Gantry (35t) 5 rail tracks
Dusseldorf	3 (35t, 50t)	4 (10t, 18t, 45t)		15 / 60	rail tracks
Ludwigshafen	1 (45t)	2 (20t, 35t)		40 / 140	
Mainz	3 (40t)	5 (35-40t)	1	5 / 7	2 rail tracks
Mannheim	2 (47t)	1 (12t)	1	25 / 33	2 rail tracks
Neuss	1 (35t)			4	rail connection
Worth	2 (40t, 47t)	4 (10t, 42t)	1		
Passau (www.bayernhafen.de)			1		
Wien (www.hafen.co.at/wien)	1 (40t)	12 (-45t) (incl. ct. stacker)	2		8 cranes (6-40t), 3 rail tracks
krems (www.wiencont.com)	1 (40t)				2 container stacker (14t, 45t), 6 rail tracks
bratislava www.spap.sk/portba	2 (20t, 36t)	3 (40t, 42t)	1		22 gantry cranes (3,2-36t), rail tracks, mobile cranes

Tab. 2-1 Transshipment facilities of selected inland ports[3]

More detailed data are available from the Manual on Danube Ports of via donau (2003). This manual contains transshipment data of all inland ports along the Danube waterway, and therefore provides a good impression of the equipment used in ports of various sizes.

First, an overview of the transshipment equipment used in all Danube ports is given in the Annex to this working paper. As can be seen from this overview, gantry cranes can have a lifting capacity between 1 and 45 tons. Mobile cranes are usually used for bulk cargo, and can therefore lift up to 100 tons at a time. Floating cranes on pontoons are less common, and moreover generally used for ship salvaging activities and the like – not for transshipment of cargo. Reach stackers, which can handle up to 45 to, have found their way in most Upper Danube ports, whereas in South-East Europe, this type of intermodal transshipment is usually confined to the larger ports.

The database available was used to investigate which type of equipment was typical of which type of port. For this analysis the correlation between the port's yearly transshipment throughput (incoming and outgoing traffic) was compared with the number of gantry cranes, mobile cranes and reach stackers in each port. The results of this regression analysis is shown in the subsequent figures.

3 **data without source declaration**: Containerisation International Yearbook 2003

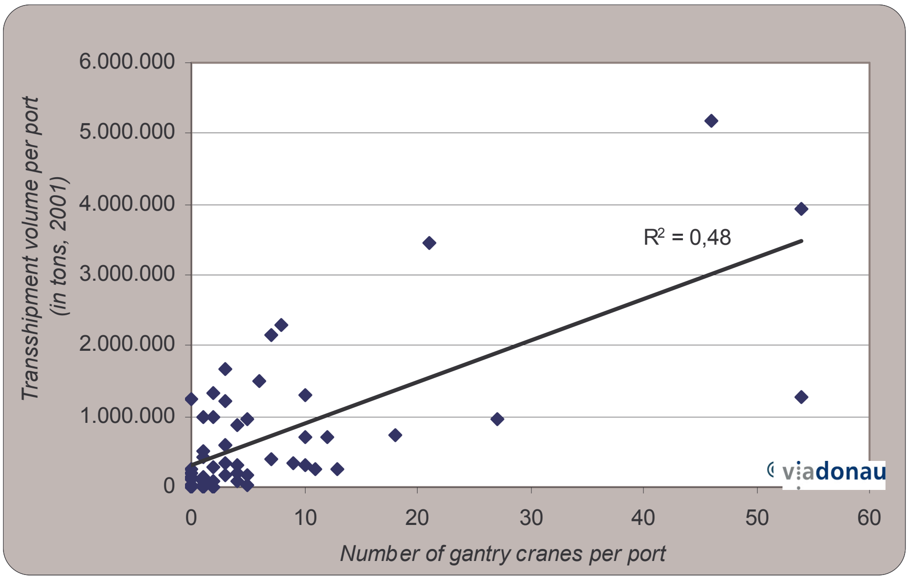


Fig. 4 Transshipment volume – number of gantry cranes

On the vertical axis, the yearly transshipment volume is shown, whereas the horizontal axis displays the number of gantry cranes used. The larger ports obviously generally dispose of more gantry cranes than do smaller ports. The regression coefficient of 0.48 does not reveal that there is a correlation between these two variables.

This obvious relationship between equipment and the scale of the port – measured in transshipment volumes – may also not be evidenced for mobile cranes and reach stackers.

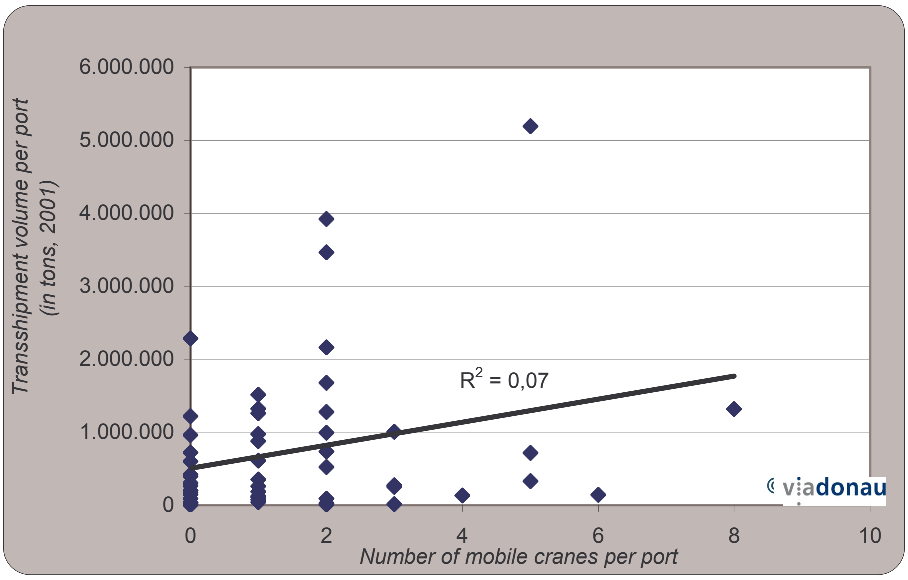


Fig. 5 Transshipment volume – number of mobile cranes

The regression coefficient of 0.07 in the above figure shows that there is practically no correlation between port size and the use of mobile cranes: these types of more flexible equipment can be encountered just as much in smaller ports as in larger ones.

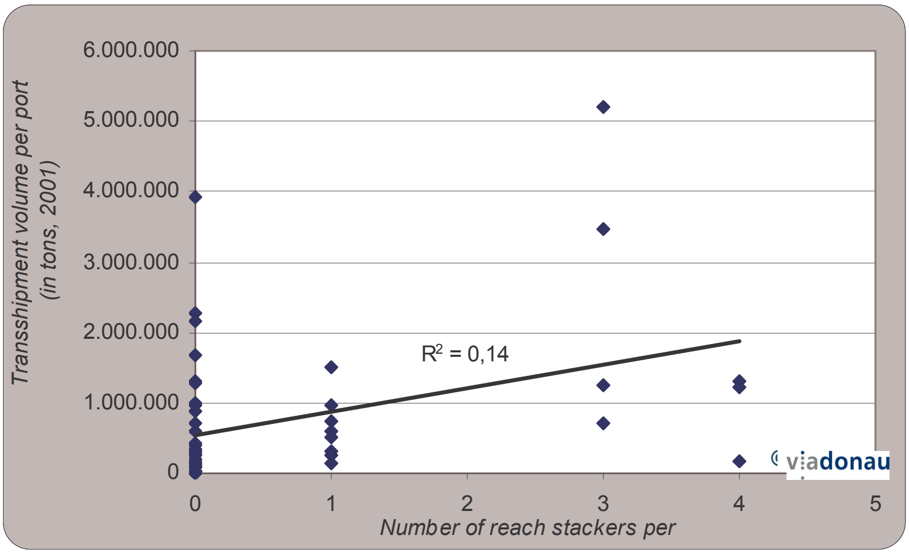


Fig. 6 Transshipment volume – number of reach stackers

The number of reach stackers used tends to be slightly larger in larger ports, but this effect is not prooved by then regression. Reach stackers are relatively small-scale investments that are equally used in both small and large ports.

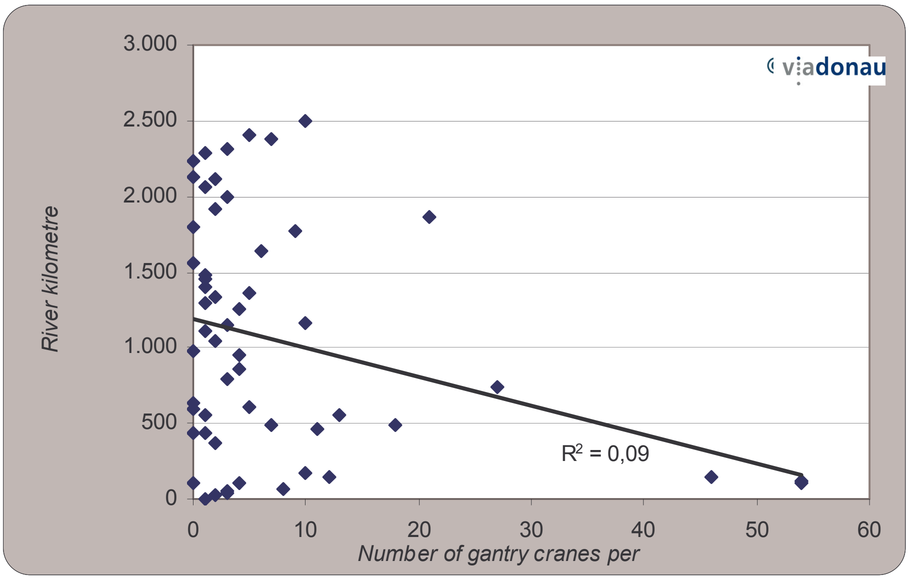


Fig. 7 Location along the waterway – number of gantry cranes

The geographical distribution of the number of gantry cranes does not show a linear relationship either. A clear relationship between the location along the Danube waterway number of mobile cranes and reach stackers is equally lacking (R^2 of 0.01 and 0.06 respectively). Along the Danube waterway, conventional means of transshipment are therefore evenly distributed – independent of the location of the port.

2.1.2 Status: Study

2.1.2.1 Barge Express

Barge Express (BEX) [4] is a concept for large scale barge container transport. The concept concentrates on the Rhine area and heavy container flows (Rotterdam-Antwerp, Rotterdam/Antwerp-Duisburg or Mainz). The BEX integrate only a small number of terminals with automatic quayside cranes, automatic guided vehicles and automatic stacking cranes. Conventional barges have to equip with cells for 20´ and 40´ containers if they take part in the Barge Express system, otherwise a new type of barge is required. (see the technical data of the 620 resp. 280 TEU barge)

The aim of the BEX is to take advantage of economies of scale by reducing the cost of sailing and handling. BEX presumes that the main barge terminals are highly automated in transshipment and internal terminal transport. This mode of inland waterway transportation assumes use of the largest possible vessels (i.e. push boat/barge combination) with cell guides. BEX transportation is principally formed between the relations Rotterdam, Germany (especially Duisburg) and Antwerp as a point-to-point connection.

There are different forms of BEX terminals planned, “active and passive” terminals.

In the active BEX terminal the terminal operator determines the sequence of containers to be picked up. Thus it needs only a small stacking area for temporary imbalance of import and export containers. An example is shown in Fig 8. Two automatic stacking cranes are working, one imports from a barge the other one exports to a barge. In this way an optimized utilisation of the transport equipment at the terminal is achieved.

Using a 620 TEU barge the following schedule with one departure a day is calculated (considering a TEU factor 1.6 TEU/container) :

Time 00:00 barge 1 arrives, barge 2 is already discharged, operation begins

Time 09:00 barge 1 is discharged (crane 1), barge 2 is loaded (cr. 2)

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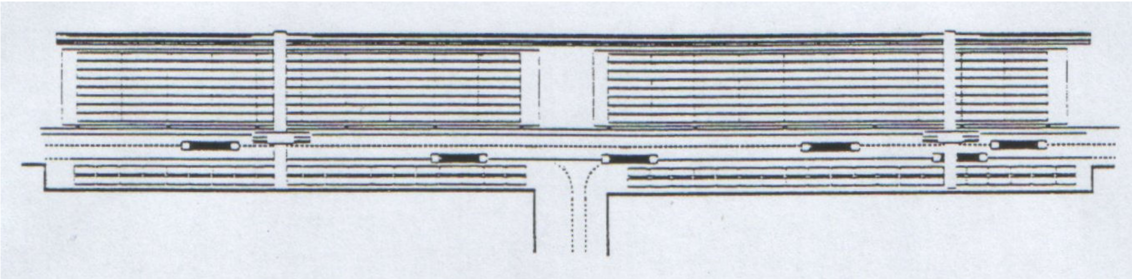
4 **Evers**, J.J.M.;Barge Express – Large Scale Automated Inland Shipping; lecture at: 17. Duisburger Kolloqium, Schiffstechnik/Meerestechnik; The ship as link in the transport chain; Duisburg 1996; **Konings**, R.; Neue Umschlagstechniken und Terminals spielen Schlüsselrolle; in: Zeitschrift für Binnenschiffahrt, Nr. 1 Januar 1999; page 48-50; **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP); Project funded by the European Community under the „Competitive and Sustainable Growth“ Programme; Date of issue of this report: June 2001.

operation stops, barge 2 leaves

Time 33:00 next barge arrives, ….

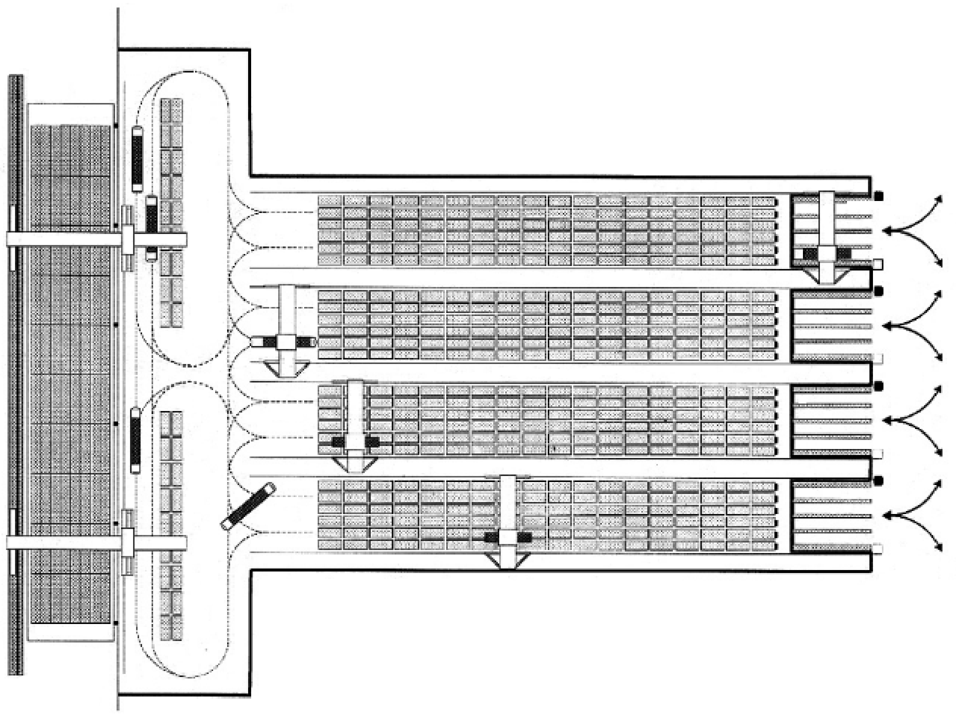


Source: **Evers**, J.J.M.;Barge Express – Large Scale Automatic Inland Shipping

Fig. 8 Barge Express (active terminal)

In the passive BEX terminal the operator has no influence on the external transport. Therefore a stacking area for containers is needed with the capacity of about 30 % more than the maximum load of one used barge.

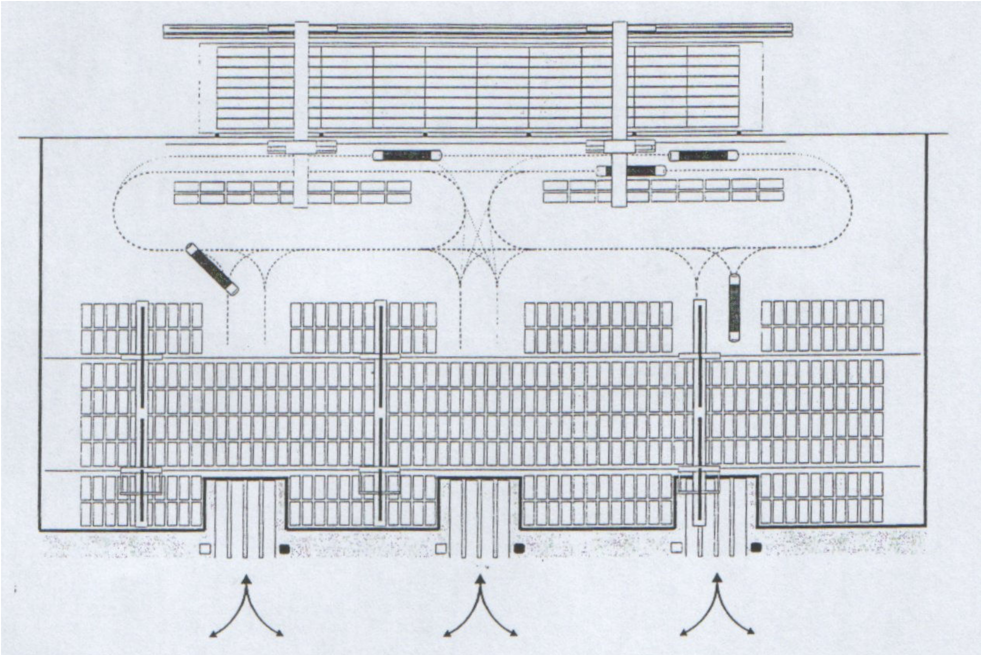
In Fig. 9 a passive terminal with four separated stacking areas is shown. Each area is operated by an automatic crane, which takes the container from the internal/external transport equipment and handles the stacking area.



Source: http://www.tbm.tudelft.nl/webstaf/jann/git6.htm

Fig. 9 Barge Express (passive terminal with separate stacking areas)

In Fig. 10 a passive terminal is shown, which contains an enclosed stacking area. All cranes (in the example three cranes) work on the whole area. In the case of a breakdown of one crane, the other ones can reach almost every container. On the other hand there must be implemented a complex control for collision avoidance.



Source: **Evers**, J.J.M.;Barge Express – Large Scale Automated Inland Shipping

Fig. 10 Barge Express (passive terminal with enclosed stacking area)

In most locations the terminal operator does not control the external traffic, so passive terminals will be used. Only in special cases (for example the ITT in the Maasvlakte/NL, where an central stacking area is used) an active terminal or a hybrid type will be chosen.

The spatial use (estimated) [5]:

Active terminal	0.6 ha	
	Length	300 m
	Width	200 m

Passive terminal 4.1 ha (separate stacking areas)

5 **Evers**, J.J.M.;Barge Express – Large Scale Automated Inland Shipping.

Length	180 m
Width	230 m

Passive terminal 3.2 ha (one enclosed stacking area)

Length	230 m
Width	140 m

Capacity of the cranes [6]

Ship to shore	45 moves per hour
Stacking Crane	30 moves per hour

Main characteristics of the barges [7]

620 TEU barge

length	144.35 m
breadth	22.89 m
depth	5.50 m
draught	3.60 m
capacity	624 TEU

280 TEU barge

length	72.00 m
breadth	22.80 m
depth	5.50 m
draught	3.60 m
capacity	280 TEU

Realisation of the Barge Express: study

2.1.2.2 Rollerbarge

Rollerbarge [8] is a concept for horizontal transshipment of containers and swap bodies between different transport modes. The main aim of Rollerbarge is to reduce transshipment time and costs. Rollerbarge needs special terminal facilities and barges. The containers are prestacked on a hydraulically operated platform. The Rollerbarges are loaded horizontally in pre-stacked blocks. An on-board lifting mechanism takes care of vertical movement of the blocks into the ship.

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6 **Evers**, J.J.M.;Barge Express – Large Scale Automated Inland Shipping.

7 **Evers**, J.J.M.;Barge Express – Large Scale Automated Inland Shipping.

8 **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP); Project funded by the European Community under the „Competitive and Sustainable Growth“ Programme; Date of issue of this report: June 2001.

On the barge the containers move horizontally to their final stowage position on board. Conventional vessels have to be adapted if they take part in the Rollerbarge system or a new type of vessel is required.

The Rollerbarge concept is similar to the cassettes system. The cassettes system was developed for the paper and steel transshipment in short sea traffic. The cassettes are loaded onto RoRo-ships. Onboard the cassettes are block wise stowed.

Capacity of the platform [9]

8, 16 or 24 units

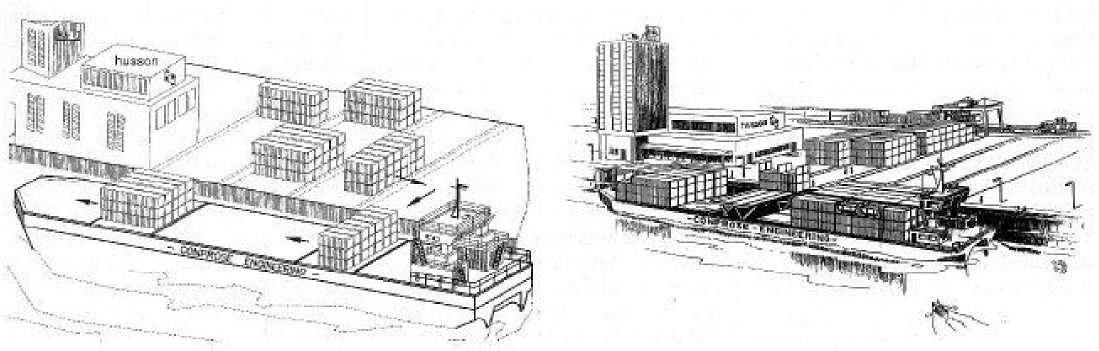
Handling capacity

100 – 120 container per hour

Capacity of the vessel (catamaran)

234 TEU vessel
312 TEU vessel

Realisation of the project: study



Source: **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP)

Fig. 11 Rollerbarge

2.1.2.3 Terminal equipment: equipment to equipment conveyor

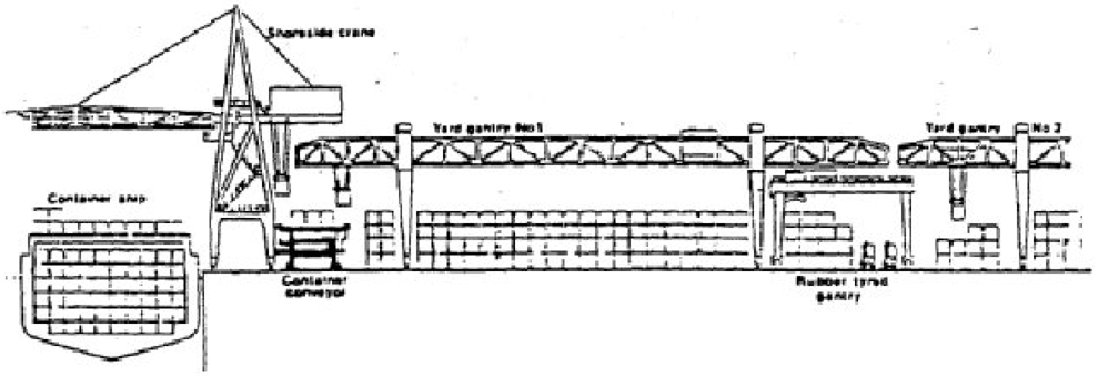
Equipment to equipment conveyor [10] can interchange containers between the Ship to Shore crane (or self (un) loading vessels) and the internal terminal transport. The concept connects the efficiency of the Ship to Shore crane with the storage area directly, i.e. without a transport mode between quayside and stacking block.

Equipment to equipment conveyor are put in with the transshipment of dry bulk and in some deep sea container terminals.

9 **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP)

10 **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP)

Realisation of equipment to equipment conveyor: in operation for maritime terminals (but not in inland waterway container terminals)



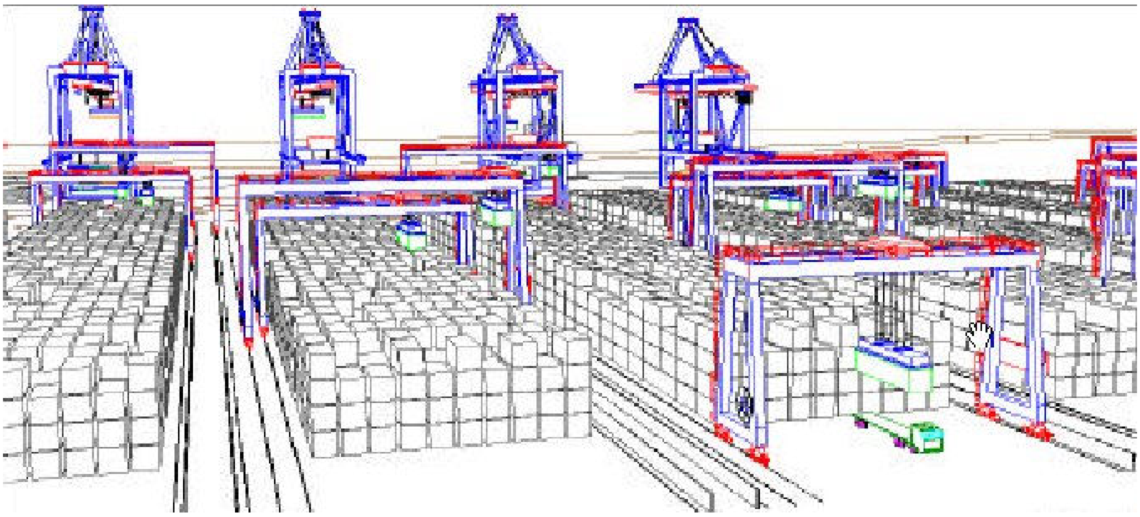
Source: **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP)

Fig. 12 Equipment to equipment conveyor

2.1.2.4 Terminal equipment: automatic stacking cranes

Automatic stacking cranes are rarely used in deep sea container terminals. In Europe this system is in usage in Rotterdam (ECT Delta Terminal) and in Hamburg (CTA). Because of the high investment costs that can not be counterbalanced by the low turnover volume of inland terminals, there are no automatic stacking cranes used in inland container terminals.

Realisation of automatic stacking cranes: in operation for maritime terminals (but not in inland waterway container terminals)



Source: CTC Container-Terminal Cuxhaven, Machbarkeitsuntersuchung, Sellhorn Ingenieursgesellschaft mbH, Hamburg 2000.

Fig. 13 Automatic stacking cranes

2.2 On-Board and Navigation Technologies

2.2.1 Status: Operational

2.2.1.1 RoRo barge transshipment

The RoRo concept addresses the road to inland waterways loading and discharging process. The concept uses roll on – roll off techniques. The idea of this concept is to redirect road-traffic to inland (shortsea) navigation. To reduce the time for transshipment and to avoid high investments in infrastructure at the terminal the usage of a roro-ramp is taken. The concepts differ in the location of the ramp as described below.

The concept can be used with accompanied and unaccompanied trailers and partly with containers, which are transported by fork lift trucks. The advantage of the accompanied trailers is the flexibility and rapidity in the transshipment process. No shunting is required, all trailers can be transshipped in a parallel manner. On the other hand the space for the tractor on board is needed and this equipment can not be used while shipping.

Regarding the small utilisation of the river Danube (about 10 to 30 % of the possible capacity) and the aspect of the not very developed road traffic net in this corridor a considerable increase of the RoRo traffic is expected.

The “pure” RoRo barge transshipment is a relatively simple type of intermodal transshipment. The port needs a conventional Roll-On/Roll-Off ramp. The trailers are driven aboard a barge.

The forwarder “Willi Betz” carried out RoRo-traffic [11] between Passau and South East Europe (“Schwimmende Landstraße”). They travel several times a week between Passau and Vidin, taking 50 semi-trailers each time. Due to the poor condition of some roads in the Balkan states this will be extended in future. To expand these options in Passau[12] a new RoRo ramp is planned.

Furthermore there is the “MUTAND” (=multimodal ro-ro transport on the Danube) [13] project, founded by the “Danube Project Centre (DPC)”, the “Entwicklungszentrum für Binnen- und Küstenschiffahrt (VBD)” and the “Via Donau Transport Entwicklungsgesellschaft”. In this project the pre-feasibility study has been carried out and came to the conclusion, that the preference is given to the implementation of Ro-Ro services rather than to container transport on account of lower initial capital investment. In phase II a feasibility Study should follow soon.

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[11] **Studiengesellschaft für den kombinierten Verkehr e.V**.: RoRo auf der Donau, in: SGKV-Rundschreiben June 2003.

[12] **Deutsche Verkehrs-Zeitung**: Jahrgang 57 Nr. 107, vom 6.9.2003, Beilage Binnenschifffahrt/Binnenhäfen, p 7

[13] **Studiengesellschaft für den kombinierten Verkehr e.V**.: RoRo auf der Donau.

Main dimensions of RCP Standard Ro-Ro Ship [14]:

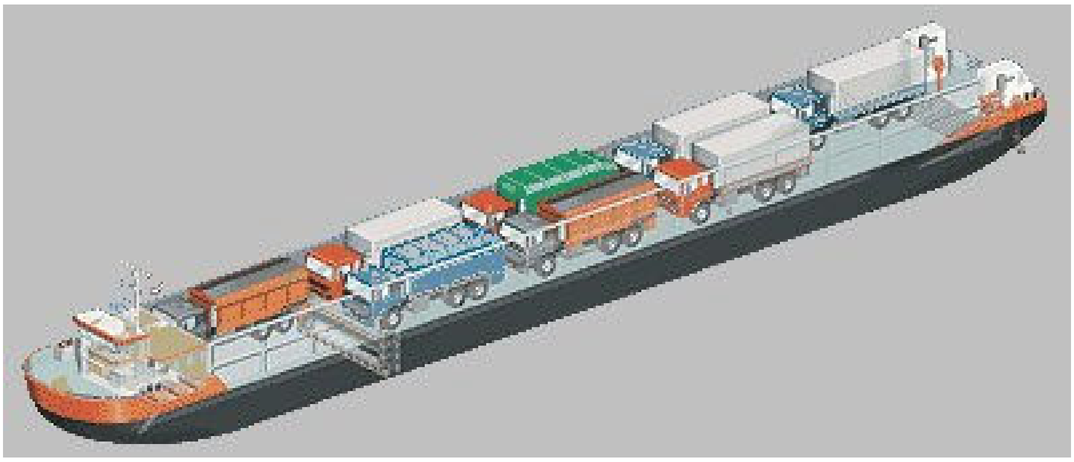
RCP Standard Ro-Ro Ship annex 90 TEU containership

length o.a.	77.50 m
breadth	7.00 m
depth	3.10 m
draught	2.80 m
capacity	90 TEU
or	10 lorries (each 40 t)

Realisation of the RoRo barge transshipment: operational

Picture source: http://www.donauhafen.de/deutsch/hafen_passau.htm

Fig. 14 RoRo barge transport and transshipment



Picture source: http://www.rcphollandpontoon.com/neokemp/examples.htm

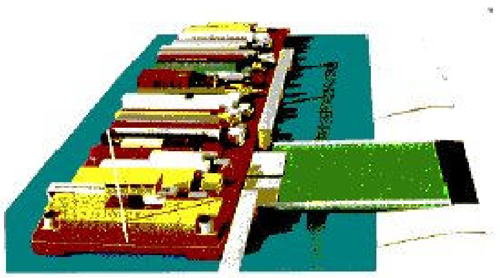
Fig. 15 RCP Standard Ro-Ro Ship annex 90 TEU containership

[14] **Ravestein Container Pontoon BV**: http://www.rcphollandpontoon.com/neokemp/examples.htm

2.2.2 Status: Study

2.2.2.1 The shwople barge concepts

The “shwople barge” is a special concept of the RoRo and needs specialized equipment at the terminal (RoRo adjustable Linkspan Berth Type “SV”). The inland waterway vessel is a wide catamaran accommodated to the semi-trailers and/or road trains. The “shwople barge” concept is developed for river/short sea services and for the Rhine (“Shwoplecat BA”). With the dimensions length 99m, width 19,5 m, draught 5 m it is able to carry 31 accompanied semi-trailers. As shown in Fig. 16 they are standing across the ship and can leave it by themselves in a parallel manner. This results in very short transshipment times and is very flexible, because every trailer is in direct access.



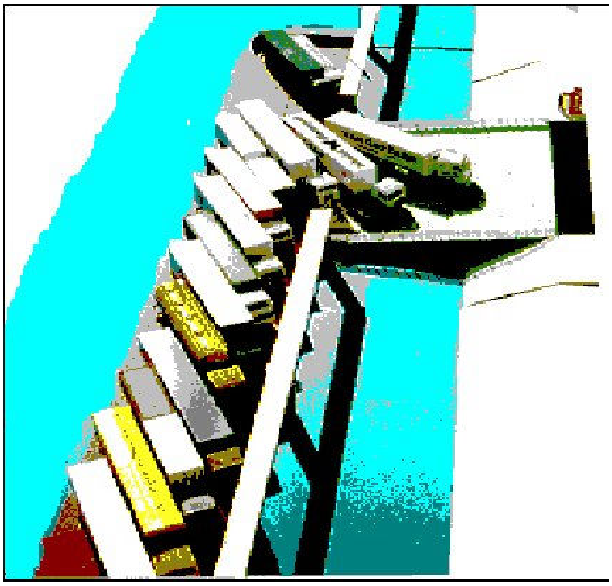
Source: **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP)

Fig. 16 Shwople barge and operation

A smaller version is the Shwoplecat AU, which is designed for the transport of unaccompanied trailers of 13.6 m (resp. accompanied lorries with this maximum size). The trailers are again positioned across the ship, the transshipment for unaccompanied trailers is more complex (see introduction to this chapter).

Also a smaller version is the Shwoplecat DA/U, where about 15 to trailers (accompanied resp. not) are transported. As shown in Fig. 17, they have to be loaded in diagonal manner across the ship. As can be seen in this picture, the transshipment is more difficult as with the shwoplecat BA because of the different orientation of trailer and RoRo ramp.

The smallest version of the Shwople barges is designed for the navigation off-rhine. Therefore the width is 11,4 m, the trailers and containers are orientated with the ship. This kind is called Shwoplecat GC. It is also operated with a RoRo-ramp from beside, the trailers have to transported with (terminal-) trucks, the containers with fork-lift-trucks.



Source: **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP)

Fig. 17 Shwoplecat BA

Main dimensions Shwoplecat BA[15]

length o.a.	99,00 m
breadth	19,50 m
draught	5.00 m
capacity	31 semi-trailers

Realisation of the Shwople barge and Shwoplecat projects: study

2.2.2.2 Floating container terminal

In case of the floating container terminal, the ship is able to sort containers during the carriage. The target market for floating container terminals are the inter terminal container flows (especially in the Port of Rotterdam). The floating container terminal collects and distributes the containers from terminals of small calls (less than 10 containers).

Main dimensions of a Floating Container Terminal [16]:

length	94.00 m
breadth	22.80 m

15 **Johan Woxenius, detached appendix to the dissertation**: Development of small-scale intermodal freight transportation in a systems context, Göteborg, 1998

16 **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP).

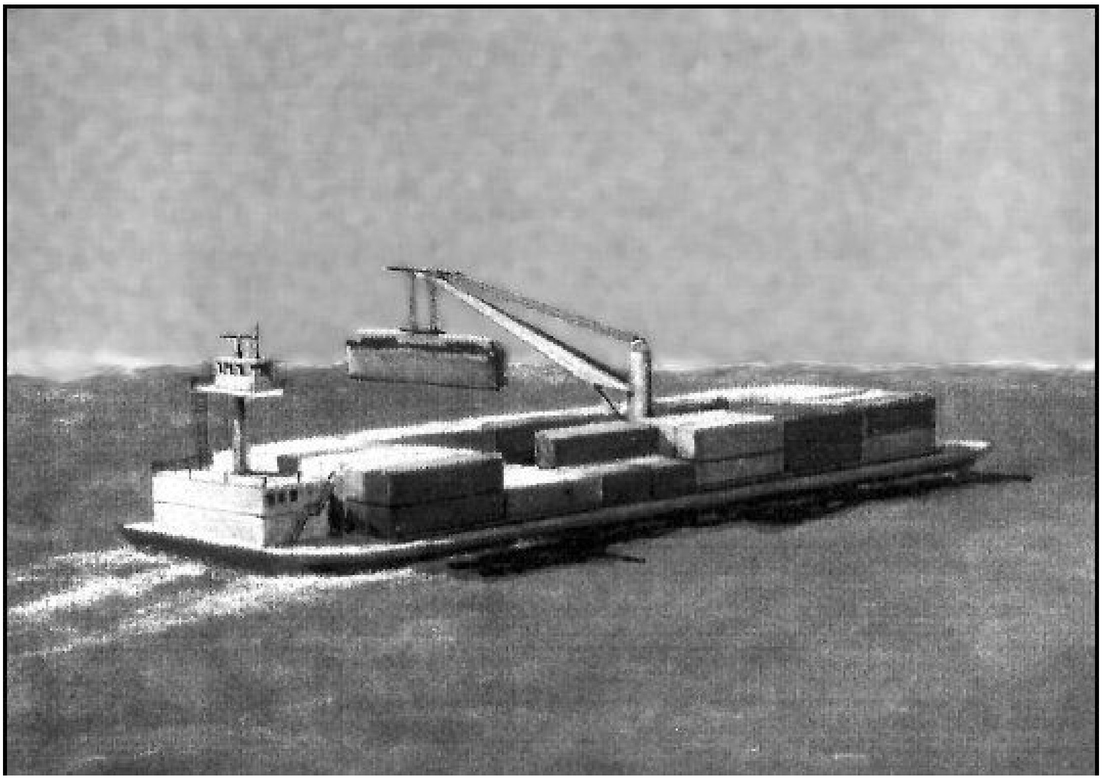
	capacity	350 TEU

Performance

	FCT crane	15-20 moves per hour
	Speed	10-15 km per hour

Realisation of the project floating container terminal: study

In the port of Hamburg a floating container terminal named port feeder barge will soon be installed for the transportation of containers between several terminals.[17] The pontoon will be equiped with a container crane and will have a capacity of 170 TEU.



Source: **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP)

Fig. 18 Floating Container Terminal

2.2.2.3 Riversnake

The riversnake is a concept for large-scale barge point-to-point transport. It works on corridors with a high volume. So it transports up to 1.300 TEU with up to nine specially designed barges. The main idea is to combine these barges in a very flexible manner,

17 **www.shortseashipping.de**: shortsea news, 22.9.2003

one tugboat in front of the barges and up to two intermediate tugboats (see Fig 19). With a width of 17 m it is smaller than the top day used double-pushed barges.

The riversnake idea was worked out F. Prins of EGM Architecten BV, NL. Although it contains 1.300 TEU it is very flexible in navigation because of the positions of the tugboats in the “snake”. It can also be used for point-to-more transports. In this case the whole “snake” can at a distribution point be split into smaller pieces, which then are transported to different destinations.

The concept was developed in competition to the Betuwe-rail-link. To achieve the same capacity, 10 to 12 riversnakes were calculated. The rail-link is in the meantime under construction, so this concept was abandoned.

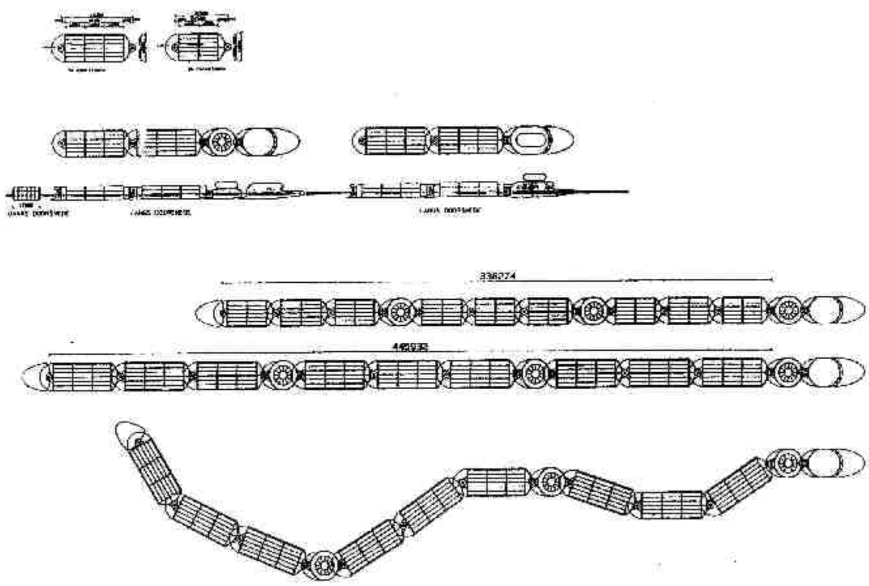


Fig. 19 Riversnake[18]

Main dimensions of Riversnake

length of one barge	36 to 44 m
breadth	17.00 m
capacity (two layers)	1.300 TEU

Realisation of the project Riversnake: study

[18] Johan Woxenius, detached appendix to the dissertation : Development of small-scale intermodal freight transportation in a systems context, Göteborg, 1998, p 131

2.2.3 Status: Vessel Designed

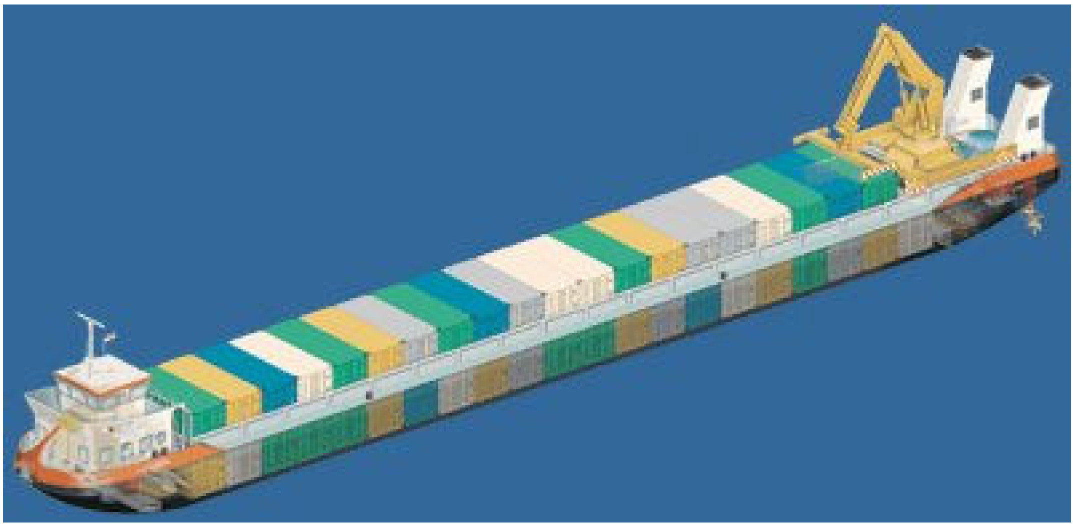
2.2.3.1 Self (un) loading ships

The self (un) loading ship is based on three different concepts:

- RoRo based, the container are driven aboard and a (automatic) crane or other conveying systems position them
- Transshipment over the bow, the board crane handles the containers over the bow
- Sideway transshipment, the crane aboard handles the container sideway on the quay

In deep and short sea shipping there exist some self (un) loading ships. Most of them handle the goods sideway at the quay. The sideway transshipment appears to be the most promising handling technique. The sideway transshipment gets wide application possibilities.

One concept for (un) loading ship is based on the neokemps barge built by the Ravestein Container Pontoon BV (RCP). The neokemps barges are far-inland container vessels which are operating for example for the CCS (Combined Container Service GmbH & Co. KG) and in Romania. The standard self–unloading 41 TEU Containership is already designed by RCP. It works with a patented ballast system to stabilize itself while transshipping.



Picture source: http://www.rcphollandpontoon.com/neokemp/examples.htm

Fig. 20 RCP Standard Self-unloading 41 TEU containership

Main dimensions of RCP Standard Self-unloading 41 TEU containership

RCP Standard Self-unloading 41 TEU containership

length o.a.	69.80 m
breadth	7.80 m
depth	3.10 m
draught	2.80 m
capacity (two layers)	41 TEU

Crane capacity

20 tons at 11 meters

Crane type

Type VMCR 260.000 ST 2-R-II

Loaded max angle

Less than 2° (patented ballast system octr.nr. 1011728)

Performance

Main engines	2 * 400 KW propulsion unit Veth-Z-400
Bowthruster	240 KW type-2-K-1000 Veth Jet

Realisation of the project Self (un) loading ship (Inland waterways): vessel designed (based on the Neokemp vessel)

Realisation of the project Self (un) loading ships: operational (short and deep sea)

Another concept is the CALCONship[19] (named by the developer group Calculus Transport Engineering – CALculus CONtainer ship).

The main idea for this concept is a revolving crane (positioned midships) with a sideway transshipment. To stabilize the ship while transshipping two fold away sponsoon tanks are available. This increases the width of the ship to 10 m.

Main dimensions of CALCONship

length o.a.	60.00 m
breadth	6.60 m
depth	3.00 m
capacity (two layers)	24 TEU

[19] Johan Woxenius, detached appendix to the dissertation : Development of small-scale intermodal freight transportation in a systems context, Göteborg, 1998

Realisation of the project CALCONship: licensed technology, not built yet

Also the concept of MONDISO, a dutch company concerning with intermodal transport technologies, included the idea of a self unloading ship. Till now this idea is not realized and mondiso nowadays concentrates an road/rail transport (see www.mondiso-intermodal.com).

2.2.3.2 River-sea barges

The main idea of this concept is to use the same push barge for the sea and river leg of a transport chain. Transshipment from barge to short sea vessel can be avoided. The main advantages of the river-sea barges are cost and time reduction. The river-sea barges are intended for point to point traffic.

Main dimensions of the Barge [20]:

length o.a.	110 m
breadth	18 m

Barge capacity

275 TEU (4 layers)
385 TEU (5 layers)

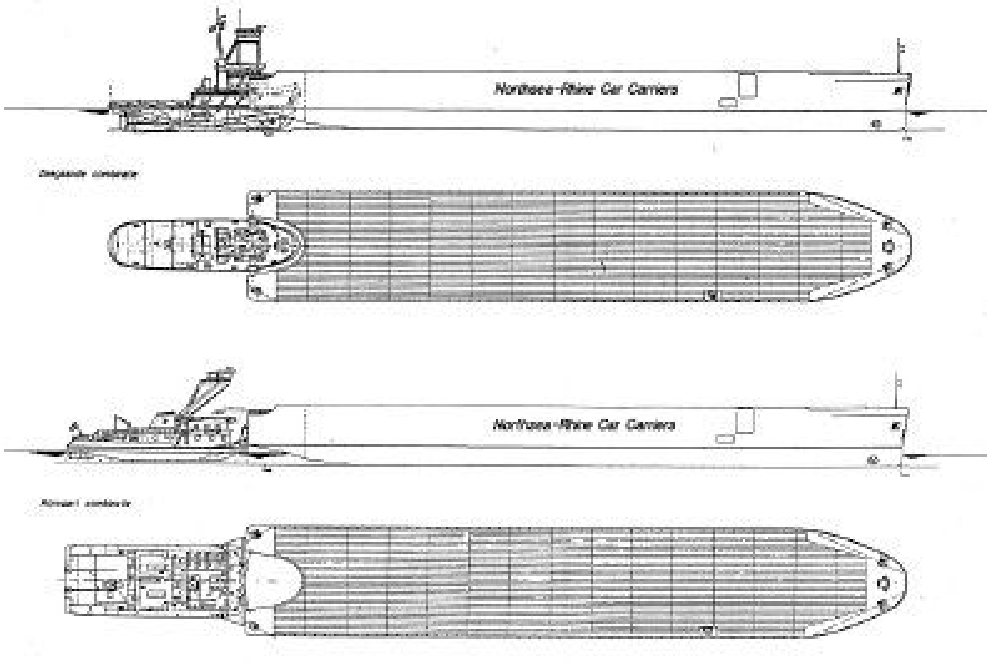
Realisation of the river-sea push-barge: study

Realisation of river-sea-ships: operational

Source: http://www.duisport.de/de/

Fig. 21 River-sea barges

[20] **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP).



Source: **Peterlini**, E. (Main Author); Innovative Technologies for Intermodal transfer Points (ITIP)

Fig. 22 River-sea push-barge

3 Comparison of Intermodal Transshipment Interfaces

This chapter implies the comparison of present and future transshipment technologies. Most of the future technologies only exist in the form of studies. Therefore the comparison between present and future transshipment technologies are based on studies.

The comparison has to be formulated on:

- Identification of the possibilities for integration of transshipment technologies in inland waterway logistic chains
- Identification of the specific requirements for new transshipment technologies
- Identification of the obstacles hampering an implementation of new transshipment technologies for waterborne transport

For the identification of the a. m. possibilities, requirements and obstacles the following questions can be defined:

- What are the most promising transshipment technologies regarding the inland waterway logistic chain?
- Which of these innovations have already been or are expected to be realized in a commercial use?
- Which of the innovations have not been integrated in inland waterway logistic chains?

The answering of these questions will be based on the results of enquiries about public literature. The main arguments pro and contra for each attended technology will be displayed in schedules, charts or matrices. The critical success factors for a new technology are:

- Transport (transit) time
- Cost
- Frequency and flexibility
- Punctuality
- Reliability
- Environmental impact
- Social acceptability

Not all of these factors are related to all technologies. There is a politically declared intention to promote intermodal transport on inland waterway. Summarizing it can be stated that all systems are supported politically. Inland navigation is the traffic mode most favorable in terms of energy consumption and environmental aspects. It can be assumed that the environmental influences are more or less equal for all technologies.

- **Which of these innovations have already been or are expected to be realized in a commercial use?**

	Status		Complexity of the technology
	inland waterway transport	other transport modes	
Transhipment innovations: quay-side technologies			
2.1.1.1 Portal and Gantry Crane/Ship to Shore Crane	operational	operational	low
2.1.1.2 Reach Stacker	operational	operational	low
2.1.2.1 Barge Express	study		very high (vessel, terminal, transshipment)
2.1.2.2 Rollerbarge	study	cassettes system in short sea shipping	high (vessel, transshipment)
2.1.2.3 equipment to equipment conveyor	study	sea container terminals	high (terminal)
2.1.2.4 automated stacking cranes	study	sea container terminals	high (terminal)
Transhipment innovations: on-board navigation technologies			
2.2.1.1 RoRo barge transshipment	operational	operational RoRo traffic	low
2.2.2.1 Shwople Barge	study		very high (vessel, terminal, transshipment)
2.2.2.2 Floating Container Terminals	study		high (vessel, transshipment)
2.2.2.3 Riversnake	study		high (vessel)
2.2.3.1 Self (un)loading ships	vessel designed	operational in short sea shipping	high (vessel)
2.2.3.2 River-sea barges	vessel designed	operational in short sea shipping (Rhine-Sea traffic)	low

Sources, please see a.m.

Tab. 3-1 Comparison of status and complexity

The technical complexity of a new technology is a main factor for success. The more complex the technique will be, the more risks will be involved in the technique. Incremental developments within the transport system have generally more potential than radical changes. The degree of dependence on other technical developments or solutions is a further aspect.

The only technologies that are in operational use are the ones with low or medium complexity. Technologies with higher complexity (this means also higher investments) are often combined with more participants who have to cooperate to get an operational system.

The simple RoRo-transshipment is in operational mode, because investments in vessels and in transshipment-technology (i.e. RoRo-ramps) is of low or medium sized dimension.

Reach stacker and gantry cranes are not related to special vessels, so in these cases no (resp. little) dependencies to other parts of the transport chains have to be regarded.

- **What are the most promising transshipment technologies regarding the inland waterway logistic chain?**

  A large number of participants take part in container/swap body transport. The more participants take part, the more the investment costs and benefits of the technique have to be spread. Every participant has to accept the new technology.

Fig. 23 Grouping of participants in inland waterway transport

	Investment		Transshipment capacity of the technology
	Costs	Investors	
Transhipment innovations: quay-side technologies			
2.1.1.1 Portal and Gantry Crane/Ship to Shore Crane	low	terminal operators	crane capacity between 15 to 30 moves per hour
2.1.1.2 Reach Stacker	very low	terminal operators	< 50% of the capacity of portal cranes/STS
2.1.2.1 Barge Express	very high (automatic gantry crane, automatic guided vehicle, automatic stacking crane)	shipowners (cooperatives, firms or individual), stevedores and terminal operators	crane capacity 45 moves per hour, handling time of a barge (capacity 620 TEU) is 9 hours min, 33 hours in schedule with optimised terminal operations
2.1.2.2 Rollerbarge	high	shipowners (cooperatives, firms or individuals), stevedores and terminal operators	handling capacity amounts to 100-200 container per hour
2.1.2.3 equipment to equipment conveyor	very high (automatic gantry crane, automatic stacking crane)	stevedores and terminal operators	dependent on the crane, comparable with gantry crane
2.1.2.4 automatic stacking cranes	high (automatic stacking crane)	stevedores and terminal operators	dependent on the crane, comparable with gantry crane
Transhipment innovations: on-board and navigation technologies			
2.2.1.1 RoRo barge transhipment	low (common RoRo barge)	shipowners (cooperatives, firms or individuals), terminal operators	200 to 400 tons per hour
2.2.2.1 Shwople Barge	high (special Shwopleship or Shwoplecat BA)	shipowners (cooperatives, firms or individuals), terminal operators	comparable with RoRo barge transshipment
2.2.2.2 Floating Container Terminals	high (special inland barge with crane)	shipowners (cooperatives, firms or individuals)	comparable with self (un)loading ships
2.2.2.3 Riversnake	high (special inland barge with tugboats)	shipowners (cooperatives, firms or individuals)	conventional transshipment facilities (see gantry crane or reachstacker)
2.2.3.1 Self (un)loading ships	low (inland barge with crane)	shipowners (cooperatives, firms or individuals)	system capacity 10 moves per hour
2.2.3.2 River-sea barges	low (push barge and special barges)	shipowners (cooperatives, firms or individuals)	conventional transshipment facilities (see gantry crane or reachstacker)

Sources, please see a.m.

Tab. 3-2 Investment cost and capacity

The Rollerbarge and the Barge Express are technologies, which require high investments in each link of the logistic chain, beginning with the yard equipement, the transshipment technologies and also specified vessels. So these technologies will only get operational, if shipowners, stevedores and terminal operators will work closely with each other. The Rollerbarge results in very short transshipment times at the vessel, but needs another transshipment from the pallet to the next transport equipment. So this technology will be used most effectively at an end node of the logistic chain.

The Barge Express in contrast will be well used for point to point transportation amidst of these chains. Concerning the very high investment costs the Barge Express network will consist of a small amount of inland ports. The same effect is seen in the oversea transport network, where the majority of vessels are calling only at small amount of european ports.

Furtheron the automatic equipment will only be used in these ports, because of the needed amount of transshipment to achieve the break even point.

The conventional RoRo traffic can be extended by demand (as to be seen in Passau), whereas the concepts of the shwople barges (in all versions) need specialised RoRo ramps and vessels (But these concepts result in shorter transshipment times). They also need a bigger amount of turnover to get the break even point. In all RoRo concepts the accompanied transport (with driver) is recommended for short trips (e.g. 8 h), while for longer trips the costs for the escorting truck and person is in no proportion to the savings in transshipment time.

The usage of self unloading ships in inland navigation must be adjusted to the usage of Ship to Shore Cranes and reach stackers in the ports. Presuming a rising turnover in the ports, the STS cranes will be chosen, concerning the bad utilisation of the on board cranes while shipping and the extended time needed by the reach stackers. Floating container terminals are designed for very short distance usage (e.g. within the port) and will not be accompanied in inland navigation.

River sea barges should be used where reasonable, e.g. in combination with short sea shipping. Using a formation of smaller lighters gets the advantage, that the formation can be split at special nodes of the logistic chain to be transported to different destinations.

The riversnake is an idea of flexible equipment usage for inland navigation, which also gets the advantage of splitting up the whole formation. It contains the highest risks of all technologies regarded, because it is a new idea, not based on well known concepts used in other links of logistic chains.

Recapitulating the most promising transshipment technologies regarding the inland waterway logistic chain are

➔ RoRo concepts, if the preliminary and downstream links in the chain are truck-transportations

➔ STS Cranes for container transshipment

➔ River sea barges, if the preliminary resp. downstream links in the chain are short sea transportations.

➔ Barge Express for only a small number of ports to generate large scale point to point traffic

- **Which of the innovations have not been integrated in inland waterway logistic chains?**

  The intermodal transport stands under high pressure by the competition of unimodal road transport. With only a few exceptions inland waterway transport is dependent on linkage with rail and road transport. For some of the new technologies, i.e. BargeExpress and Rollerbarge it is necessary that the technology is available everywhere.

	Possibilities of use in the entire inland waterway network
Transhipment innovations: quay-side technologies	
2.1.1.1 Portal and Gantry Crane/Ship to Shore Crane	Wide possibilities for usage
2.1.1.2 Reach Stacker	Wide possibilities for usage
2.1.2.1 Barge Express	Concept for large scale barge container transport, Minimum year capacity is 175.000 TEU per route
2.1.2.2 Rollerbarge	Concept for large scale container flows
2.1.2.3 equipment to equipment conveyor	Concept for large scale container flows
2.1.2.4 automated stacking cranes	Concept for large scale container flows
Transhipment innovations: on-board technologies	
2.2.1.1 RoRo barge transhipment	Wide possibilities for usage
2.2.2.1 Shwople Barge	Concept for large scale container and roro goods flows
2.2.2.2 Floating Container Terminals	Concept for large scale container flows, used for short distance transports
2.2.2.3 Riversnake	Concept for large scale container flows with the possibility to split the volume into 2 or 3 parts, which can be transported to different destinations (point-to-3point)
2.2.3.1 Self (un)loading ships	Wide possibilities for usage
2.2.3.2 River-sea barges	Supplement to the short sea shipping

Tab. 3-3 Applications and distribution of the technology

As mentioned above, the technologies with the lowest costs and with the smallest dependencies to other links of the logistic chain are operating just now. The other ones are combined with high investments. They will only get operational, if all partners in the logistic chain will cooperate very closely.

One example for such a logistic chain concept is the company Combispeed in Lübeck, which will operate the Hamburg-Lübeck land bridge (Baltic bridge). The nodes of this bridge are the deep-sea terminals in Hamburg on the one hand and the short sea terminals in the Baltic Sea on the other side. The shareholders of the company are the terminal operator in Hamburg (Hamburger Hafen- und Lagerhaus AG/HHLA) and a forwarder from Lübeck (combisped). They offer the complete logistic chain via Lübeck from Hamburg to the Baltic sea terminals or even (on demand) to the inland end customer in Scandinavian countries.

This example shows, that great efforts have to be made to install an superior logistic chain for large scale container flows. Partners have to be found to cooperate in the specified manner to be able to finance the high investments.

4 Summary and Conclusions

The rail and road transport modes achieved their limits on many traffic relations. The development and improvement of inland waterway transport is essential for a substantial European transport infrastructure especially as the utilisation of these waterways is very low nowadays. For example the river Danube is utilized by some 10 to 30 % today[21]. The waterborne transport has a major advantage. Waterborne transport features the capability of transport of huge volumes with low environmental impacts. So a study states, that the environmental costs of inland navigation are about only 7 % of the environmental costs which are caused by truck transportation[22]. Therefore will the use of inland waterways the positive impacts on environmental conditions increase.

The further integration of inland waterway transport in intermodal chains – and the contribution of improved transshipment – interfaces is the central theme of this SPIN Working Paper. Several measures are to be taken in order to improve the intergration of IWT in intermodal chains. These are summarised in the figure below.

Transshipment is the key to success in multi-modal transport. Faster and cheaper transshipment is an essential condition for integration of waterborne transport into the multi modal transport chain. The high investment cost in new transshipment technologies hamper the willingness to introduce in new concepts and technologies. The possibility to use inland waterway 24 hours over the whole year is one of the most important requirements for the integration of inland waterborne transport into the logistic chains. Especially this requirement is essential for the smaller European waterways.

21 **Deutsche Verkehrs-Zeitung**: Jahrgang 57 Nr. 107, vom 6.9.2003, Beilage Binnenschifffahrt/Binnenhäfen, p 7

22 www.passau.ihk.de/service/pub/downloads/merkblaetter/donauausbau.pdf

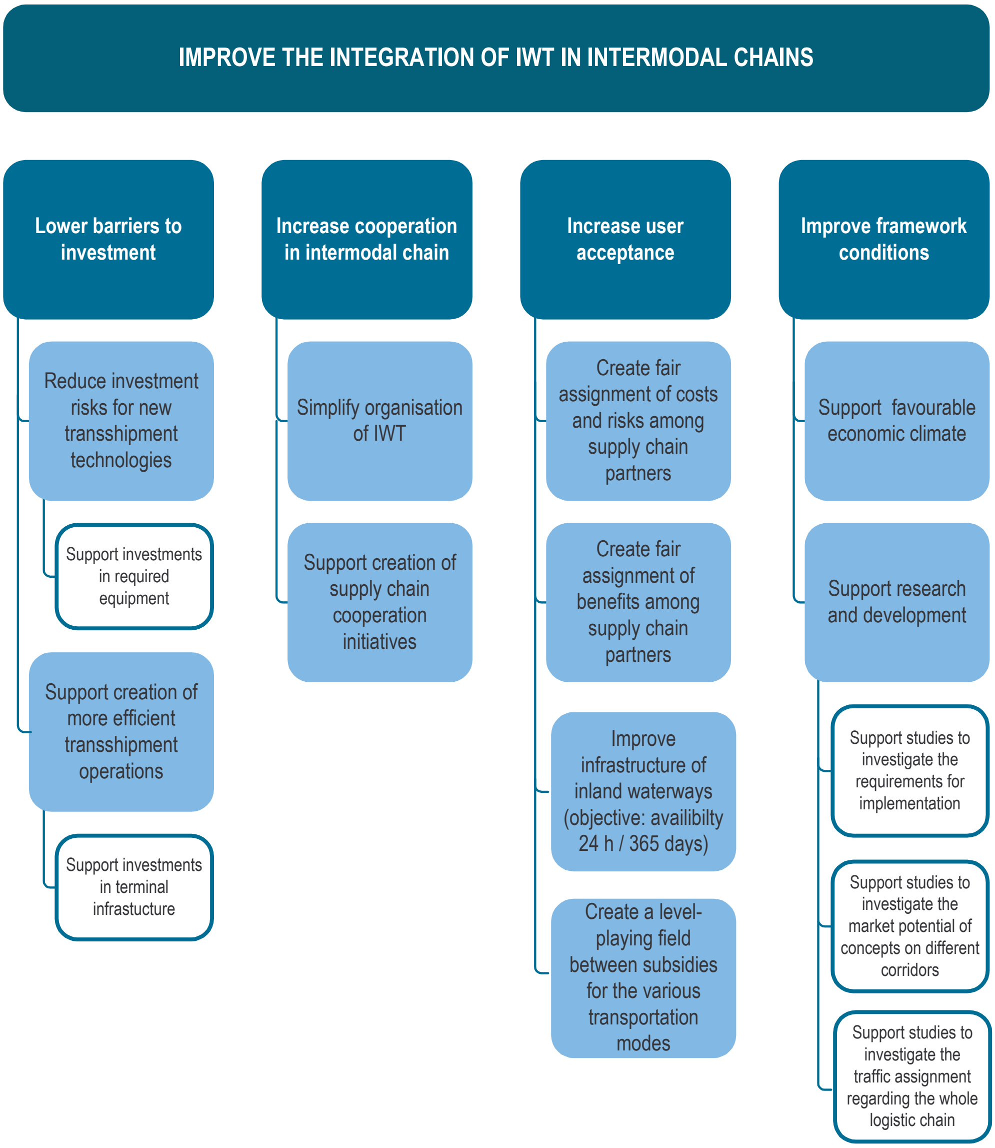


Fig. 24 Catalogue of measures to improve transshipment interfaces

One obstacle is the organisation of inland waterway transport. There are a lot of smaller companies (carriers and terminal operators) who have to work together very closely to finance this high investments. One example for such cooperation is the Hamburg-Lübeck land bridge operated by the company Combispeed. Therefore it is not clear how investment and risk management can be realized and consequently the logistic integration will go slow.

A large number of participants take part in container/swap body transport. Every participant has to accept the new technology. Some new transshipment technologies need new forms of commercial contracts between the participants.

Barge transport is a large-scale transport system. The existing barge fleet and most of the terminals along the waterways are designed for traditional handling technologies.

The development of an intermodal transport system is hindered by several problems. The technological improvements of the transport modes are different. Rail transport is lagging in comparison with the other modes of transport especially in terms of improvement of automated guided vehicles and automatic handling systems.

The introduction of completely new systems will be difficult, if there is no significant advantage. New technologies have to benefit equally to all participants in inland waterway transport.

The development of new technologies will take several decades. Every new technology goes through the phases of the development cycle:

- Innovative idea
- Scale model
- Prototype
- Demonstration model
- Market introduction

New technologies in inland waterway transport systems have to promote the interests of all participants. New technology has to compete with existing technologies. It has to facilitate equality to all transport modes and provides open access for all parties.

There are four key factors that affect innovations

- Economic facts
- Government intervention
- Changes in transport demand
- Business and social environment

Economic facts such as economic growth, competition and the quality of management may have a great influence on innovations. During a period of economic growth the level of investment tends to be much higher than in periods of stagnation or recession. The level of competition is another fact. A high level of competition may give reasons to invest in technologies while too strong competition could have a negative influence. Furtheron the innovation “mindness” of the management may influence the technology investments.

The European and national governments have to create positive economic conditions: They have several political instruments to influence the investment trend in new technologies. One of them is transport policy. Government interventions are such as high taxes on some fuels or various subsidies. Another alternative for the government is to spend public money on research and development on behalf of the transport economy. A growing importance for the transport sector will be the environmental policy. Environmental policy involves vehicles and infrastructure regulations.

The changes in demand affect the transport industry. As a result of these changes the transport industry develops new (types of) vehicles, new modes and services. The changes of demand affect the quantitative and qualitative terms of the transport services. Some innovations are the result of the competition between different transport modes. The different modes are at pains to improve its performances, in terms of costs, transit time, reliability and transport capacity. The government should take care that it does not warp this process by political instruments. For example interprets the DVZ a just published study from the PLANCO consult GmbH (Essen) in way that the position of the inland navigation does not suit to the political manifestos[23]. Smaller container terminals which are easily to handle can be the most promising innovation. The container crane in this terminals could be self operated by the skipper. The combination of small container terminals and small, fast container ships such as the Neokemps, can be a step in a wide dispersion of container inland waterway transport in Europe.

Recapitulating this statements and the results of chapter three the following steps are recommended :

- The greatest increase in inland navigation traffic is expected in container/swap body transportation, while the bulk cargo is still widely used in navigation. Therefore the following statements concentrate on this area.
- Most of the regarded technologies are used in other transport modes (e.g. short sea shipping), so it is not necessary to make more investigations on the technical feasibility of the recommended concepts. Further studies should concentrate on the assistance of their implementation. The two main aspects are :
    - To investigate which concept is suitable for which relation and
    - to subsidize investments in the needed equipment
- As shown in Chapter three, the Barge Express concept will only work on point to point services with large scale container transportation. So it should be investigated which inland (and perhaps short sea) ports will be chosen for this distribution nodes. As remarked, the transportation network of these nodes should be very small with long distances between the nodes. Traffic models can be used, to determine the possible allocation of nowadays truck or rail traffic volumes.
- For relations and corridors, where such large scale transportations are not found, it has to be investigated, if the RoRo concepts or container flows with Ship to Shore cranes as well as flexible and fast container ships (like Neokemps) are a convenient solution. This depends (as remarked in chapter

[23] **Deutsche Verkehrs-Zeitung**: Jahrgang 57 Nr. 132, vom 4.11.2003, „Planco-Gutachten: Binnenschiffern den Rücken stärken“ , p 1, cover story

three) on the travel distance and the kind of transportation mode on the previous and next links of the used logistic chain. Thus inland navigation can not be regarded separately.

- The realisation of technical requirements should be subsidized by governments. This might be done by facilitating the investments in new vessels and transshipment equipment. It seems to be a good time for such investment programs, because the navigation fleet is already overaged nowadays. The owners are not willing to invest, because of the risks of uncertain future. If this programs are designed in that way that cooperations are funded, it will be a stimulation for several parts of the logistic chain. Thus also the high investment should be affordable.
- Traffic politics have to ensure fair general conditions for all traffic modes and should consider also the environmental assets and drawbacks. In inland navigation the above-named obstacles in infrastructure have to be removed.

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Index of Abbreviations

BEX	Barge Express
IWT	Inland waterway transport
RoRo	Roll on, Roll off

Annex: Transshipment equipment used in Danube Ports, Source: via donau, Manual on Danube Ports, Vienna, 2003

country	port	gantry cranes	mobile cranes	floating cranes	forklifts up to 5t	reach stackers
Germany	NUREMBERG	10 (40t)	0	0	0	3
	KELHEIM	5 (45t)	1 (16t)	0	10	1
	REGENSBURG	7 (45t)	2 (64t)	0	0	0
	STRAUBING	3 (3-35t)	0	0	0	0
	DEGGENDORF	1 (35t)	2 (22-25t)	0	0	1
	PASSAU	0	1 (40t)	0	0	0
Austria	LINZ	0	1 (32t)	0	12	3
	ENNSHAFEN	2 (40t)	3 (20t)	0	10	0
	YBBS	1 (6t)	6 (3-50t)	0	12	1
	KREMS	3 (50t)	1 (5t)	0	15	1
	VIENNA	2 (10-35t)	1 (33t)	0	35	4
Slovak Republic	BRATISLAVA	21 (4-36t)	2 (16-28t)	0	8	3
	KOMÁRNO	9 (8-32t)	1 (17t)	1 (16t)	6	0
Hungary	GYÖR-GÖNYÜ	0	3 (8-50t)	0	3	0
	KOMAROM	0	0	1 (5t)	1	0
	BUDAPEST	6 (12-32t)	1 (30t)	0	14	1
	DUNAFÖLDVÁR	0	1 (8t)	0	3	0
	BAJA	1 (15t)	0	2 (40t)	4	0
	MOHÁCS	1 (14t)	0	0	5	0
Croatia	OSIJEK	5 (5-20t)	1 (50t)	1 (6t)	12	4
	VUKOVAR	2 (5-6t)	1 (63t)	0	5	0
Serbia & Montenegro	APATIN	1 (6t)	1 (50t)	0	1	0
	BACKA PALANKA	1 (6t)	0	0	1	0
	NOVI SAD	4 (5-27t)	0	0	8	0
	BELGRADE	10 (6t)	0	0	49	1
	PANCEVO	3 (20-28t)	5 (18-33t)	1 (5t)	20	0
	SMEDEREVO	1 (1t)	2 (10t)	2 (16t)	0	0
	PRAHOVO	4 (1-10t)	0	0	1	0
Bulgaria	VIDIN	3 (10-16t)	0	0	2	0
	LOM	27 (5t)	0	0	5	0
	ORYAHOVO	3 (5-20t)	0	0	2	0
	SOMOVIT	5 (5t)	0	0	0	0
	SVISHTOV	13 (5-20t)	1 (12t)	0	14	0
	ROUSSE EAST	18 (5t)	2 (16t)	0	7	1
	ROUSSE WEST	11 (5-20t)	0	0	7	1
	TUTRAKAN	1 (1t)	0	0	0	0

Annex: Transshipment equipment used in Danube Ports (cont'd), Source: via donau, Manual on Danube Ports, Vienna, 2003

country	port	gantry cranes	mobile cranes	floating cranes	forklifts up to 5t	reach stackers
Romania	MOLDOVA VECHE	2 (5t)	0	0	0	0
	DRENCOVA	1 (10t)	0	0	0	0
	TISOVITA	0	0	2 (16t)	0	0
	ORSOVA	4 (4t)	2 (16-25t)	4 (16t)	1	0
	DROBETA TURNU SEVERIN	2 (5t)	0	0	0	0
	GRUIA	0	0	2 (16t)	0	0
	CETATE	0	0	2 (16t)	0	0
	CALAFAT	2 (5t)	1 (16t)	1 (10t)	0	0
	BECHET	0	0	2	0	0
	CORABIA	0	0	0	0	0
	TURNU MAGURELE	0	4 (5-16t)	0	0	0
	ZIMNICEA	1 (25t)	3 (16t)	0	0	0
	GIURGIU	7 (5-16t)	0	0	0	0
	OLTENITA	0	2 (5t)	0	0	0
	CALARASI	2 (5t)	2 (5-16t)	0	0	0
	CERNAVODA	3 (5-16t)	0	0	0	0
	MEDGIDIA	3 (5-16t)	2 (5t)	0	0	0
	BASARABI	2 (5-16t)	3 (6t)	0	1	0
	CONSTANTA	5 (16-20t)	61 (12-250t)	27 (35t)	100	90
	HARSOVA	0	0	2 (16t)	0	0
	TURCOIA	0	0	0	0	0
	MACIN	2 (2-5t)	0	0	0	0
	GURA ARMAN	1 (16t)	0	0	0	0
	BRAILA	10 (5-16t)	8 (16t)	3 (30t)	3	0
	GALATI DOCURI	12 (12t)	5 (25-60t)	3 (32t)	0	0
	GALATI ROMPORTMET	46 (16-25t)	5 (50-63t)	1 (32t)	5	3
	GALATI BAZINUL NOU	10 (10t)	12 (16-50t)	4 (32t)	27	2
	ISACCEA	0	0	1 (5t)	0	0
	TULCEA	8 (5-16t)	0	1 (32t)	3	0
	MAHMUDIA	3 (3t)	0	0	0	4
	SULINA	0	0	5 (32t)	1	0
	CHILIA VECHE	1 (1t)	0	0	0	0
Ukraine	RENI	54 (5-40t)	2 (36-50t)	3 (100t)	26	0
	IZMAIL	54 (6-40t)	2 (20-50t)	4 (16t)	0	0
	KILIA	4 (4t)	0	1 (5t)	6	0
	UST-DUNAYSK	4 (4t)	1 (21t)	8 (50t)	8	0