Instituto Panamericano de Ingeniería Naval
Instituto Pan-americano de Engenharía Naval
Pan-american Institute of Naval Engineering

XI CONGRESO PANAMERICANO DE INGENIERIA NAVAL,
TRANSPORTE MARITIMO E INGENIERIA PORTUARIA.

THE INTEGRATED PUSHER BARGE SYSTEM, A COST EFFECTIVE TRANSPORTATION SYSTEM

PAPER N° 32

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1. Introduction

One of Wärtsilä Marine's R & D projects in the mid 1970 was to develope more cost effective sea transportation solutions. One of the most promising alternative was the integrated pusher barge concept. It was soon found out that none of the existing connection systems were reliable enough, however.

Since reliability in sea transportation is a requirement that cannot be compromised the solution was to develope a totally new and absolutely reliable connection system. The new sea transportation concept, Wärtsilä Marine Locomotive, was ready in the early 1980.

The benefits of pusher barge operation are results of the fact that the engine room and accommodation part can be disconnected from the rest of the ship. This "drop and swop" feature results in a high turnaround frequency since there is no idle time for the pusher and crew. Since the barge can stay longer in the harbour than a conventional vessel there is usually no need for high capacity loading and discharge facilities, but only simple cargo handling.

The first pusher barge system of Wärtsilä Marine Locomotive type has been in operation in the Baltic sea for some three years. This system consists of two pushers and five 14 000 tonne deadweight barges. This fleet is owned by Rautaruukki Oy, a Finnish steel company, and is managed by a Finnish shipmanagement company Finnlines Ltd.

2. Development of the Connection Concept

The aim of the development work was to design a pusher barge system with the same operating reliability as a conventional ship has, but which at the same time give maximum gain of the drop and swop feature. This work included two main tasks, to develope a new connection concept and to develope necessary locking devices.

The main requirements for the connection concept were:

- unrestricted operating area
- quick connection and disconnection
- connection to be possible in all draft combinations.

The result of the development work was a concept utilizing a rigid three point connection system, allowing the pusher to be connected to the barge at different drafts of the barge. The pusher has a tapered hull from to allow easy entering into the notch of the barge. While the pusher is equipped with the movable connection units, the barge has only simple connection notches. These notches are located at two to four levels to allow connection at different drafts.

The rigid three point connection concept resulted in following requirements for the connection devices:

- simple construction
- prestressed connection.

By using unsymmetrical wedges in the side units of the pusher, it was possible to use a fixed wedge in the bow, and still achieve both longitudinal and transverse prestressed connection. The connection concept is shown in Figure 1.

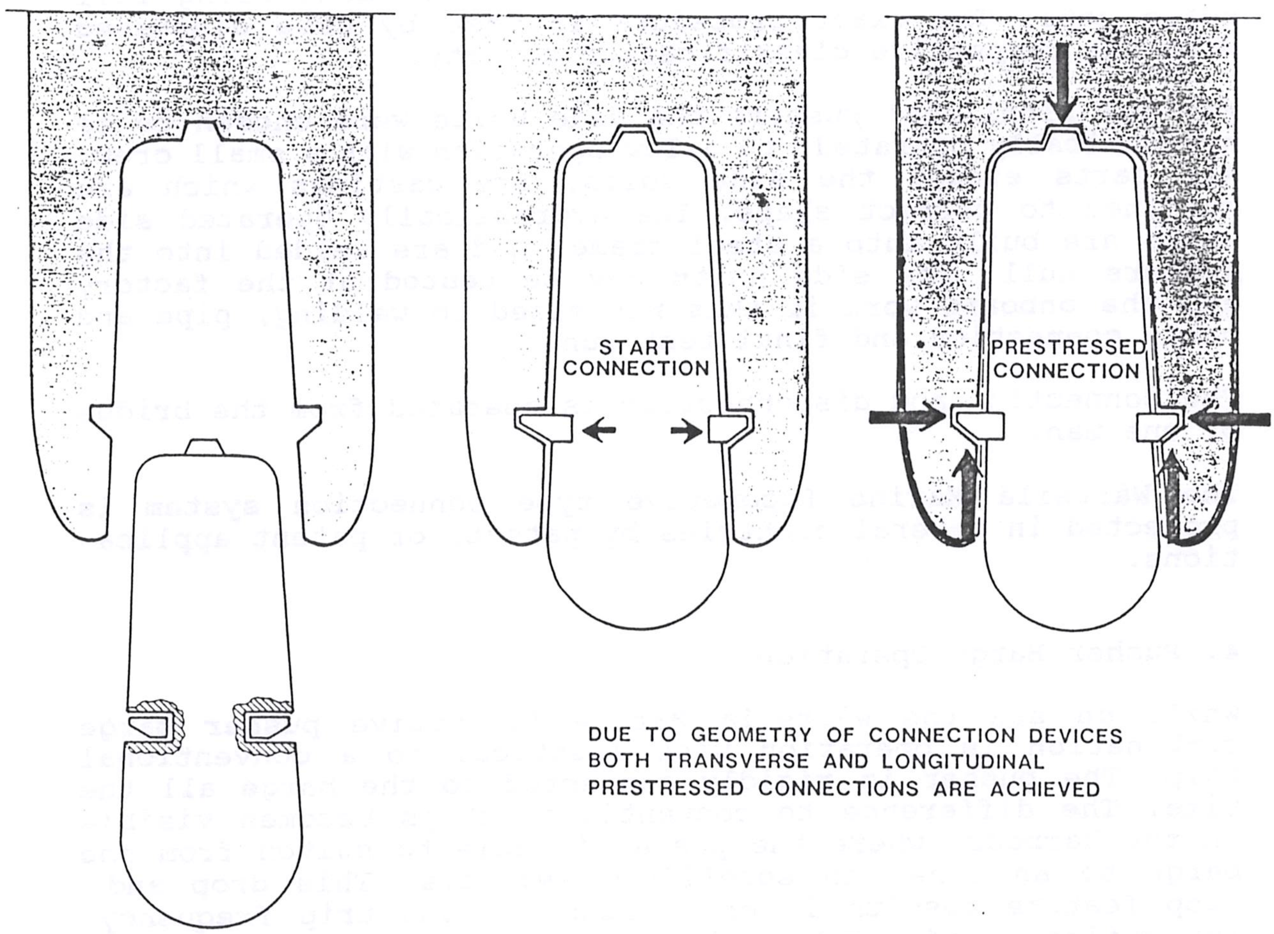


Fig. 1 The connection of the pusher into the notch of the barge.

3. The Connection System

As earlier described the connection system is based on a rigid three point connection concept. One of the connections points consists of a fixed cone in the bow of the pusher, and corresponding notch in the barge. The side connection points consists of movable unsymmetrical wedges in the sides of the pusher. These wedges cause the rigid prestressed connection. Strength wise these three connection devices have to bear the same forces as the complete hull section of a ship.

Although it might seem to be as looking for problems when one tries to lead all forces through only the three connection points, the task is not that difficult. The main problem is, not surprisingly, to define the design forces for the connection devices. This work, which is carried out in close cooperation with the respective classification society, can be reasonably accurately done using various calculation methods. The calculated forces should be checked and verified by model scale testing unless this can be done using full scale data. The exact procedure is case by case discussed with the respective classification society.

For the Finnlines' pushers the side units were chosen to be hydraulically operated, to allow operation with a small crew. All parts except the side units, are castings which are machined to correct shape. The hydraulically operated side units are built into a steel frame, and are welded into the pushers hull. The side units may be tested at the factory and the onboard work is thus minimized to welding, pipe and cable connection and final test run.

The connection and disconnection is operated from the bridge by one man.

The Wärtsilä Marine Locomotive type connection system is protected in several countries by patents or patent applications.

4. Pusher Barge Operation

While on sea the Wärtsilä Marine Locomotive pusher barge combination is operation wise identical to a conventional ship. The pusher is rigidly connected to the barge all the time. The difference to conventional ships becomes visible in the harbour, where the pusher is able to switch from one barge to an other in somefifteen minutes. This drop and swop feature results in an increased round trip frequency. The optimal configuration includes in most cases one barge for each pusher and each harbour, Figure 2.

Theoretically a configuration of one pusher and three barges can achieve the same round trip frequency as three conventional vessels. This is possible on short routes when the

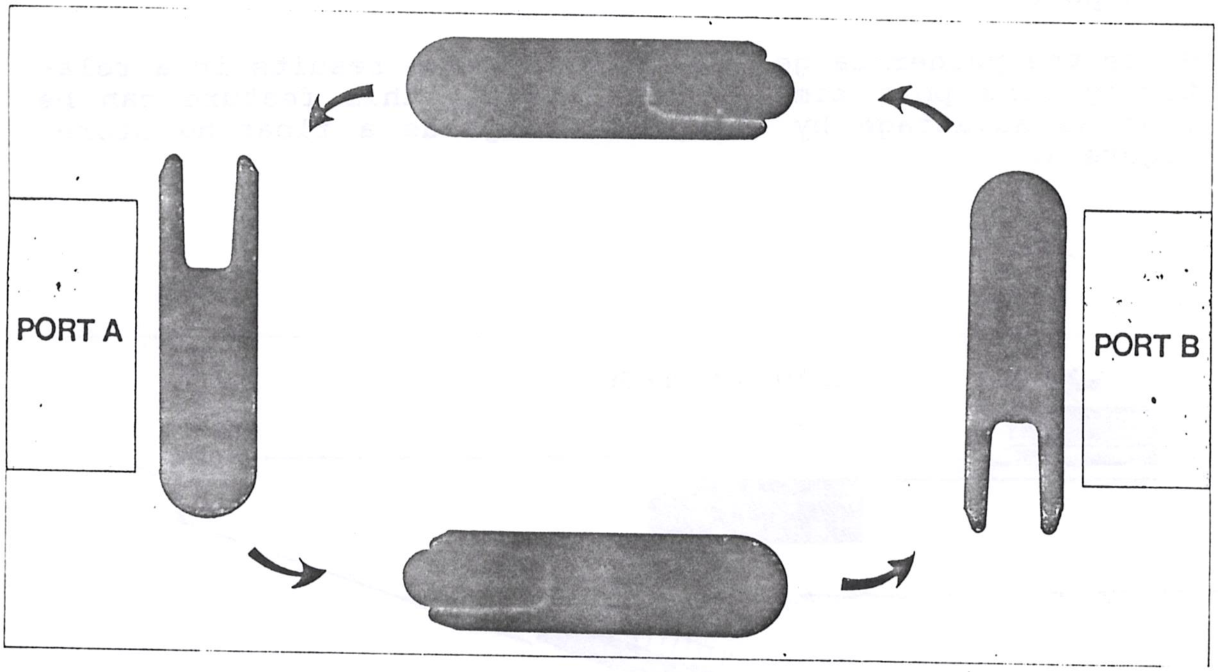


Fig. 2 An optimal pusher barge configuration includes one barge for each pusher and each port. The pushers may then be in operation all the time.

loading and unloading time are long. Even though the harbour time-sea time-ratio does not allow such a high utilization of the drop and swop feature, it is still in many cases, especially on short routes such as are usual in coastal shipping, able to do a much higher round-trip figure than the equal (to pushers) number of conventional ships.

Due to the quick disconnecting and connecting times the pusher is able to do the port visit in about one hour, unless delayed by customs procedures, bunkering or other reasons. Still a harbour time of two hours for a bulk carrier of 14 000 tonne deadweight sounds like utopia. For a Wärtsilä Marine Locomotive type pusher barge combination it is a recorded routine. The extremely low harbour time can be used to achieve a high turn around frequency, or the necessary cruising speed may be lowered, in which case a smaller main engine power can be chosen, and operating cost savings can be made.

Since it is not necessary to minimize the harbour time of the barge in the same extent as a conventional ship, the requirements for cargo handling speed is remarkably lower. When the pusher barge fleet consists of e.g. one pusher and three barges, the total turnaround time of the pusher is available as port time for each barge in both harbors. For a route length of 240 nautical miles and average cruising speed of 12 knots, this gives an port time of 44 hours for the barges, if it is assumed that the pusher is two hours in each port.

Since the pusher barge operating sequence results in a relatively long port time for the barges, this feature can be used as advantage by using the barge as a floating store, Figure 3.

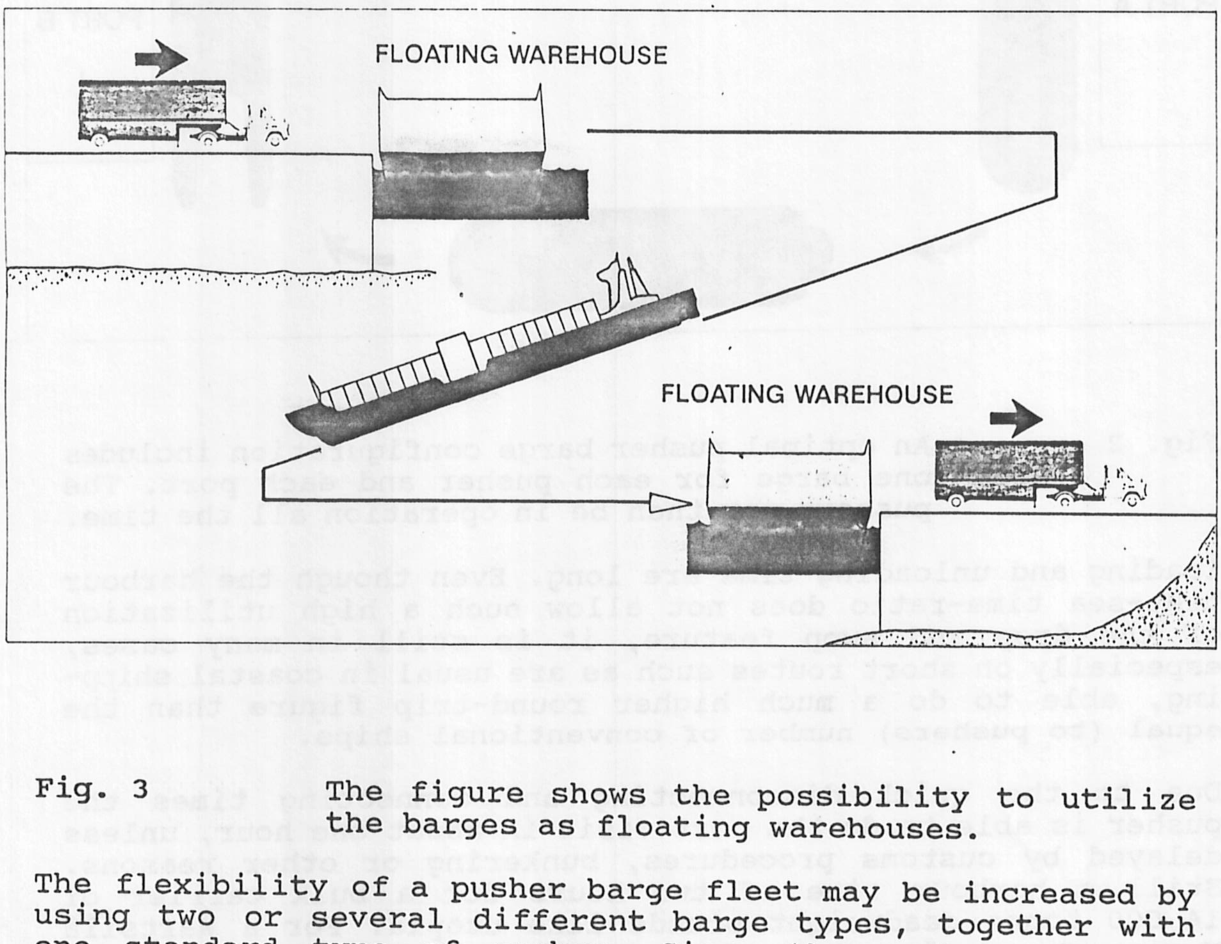


Fig. 3 The figure shows the possibility to utilize the barges as floating warehouses.

The flexibility of a pusher barge fleet may be increased by using two or several different barge types, together with one standard type of pusher. Since the pushers are not dedicated to any certain type of barge, but can be used together with any of these barges, additional flexibility is added to the fleet, when comparing to a fleet of a few conventional ships of different types. Not only the barge type may alter, also the size can vary a lot. For the pusher barge system in use in the Baltic, barges ranging from some 6 000 to 60 000 tonne deadweight could be added, Figure 4, and still the existing pusher could be used.

The features described in this section show that a coastal shipping operation can be built up using one standard pusher and a few different types of barges. The parallel to road transportation using trucks and trailers is easy to see.

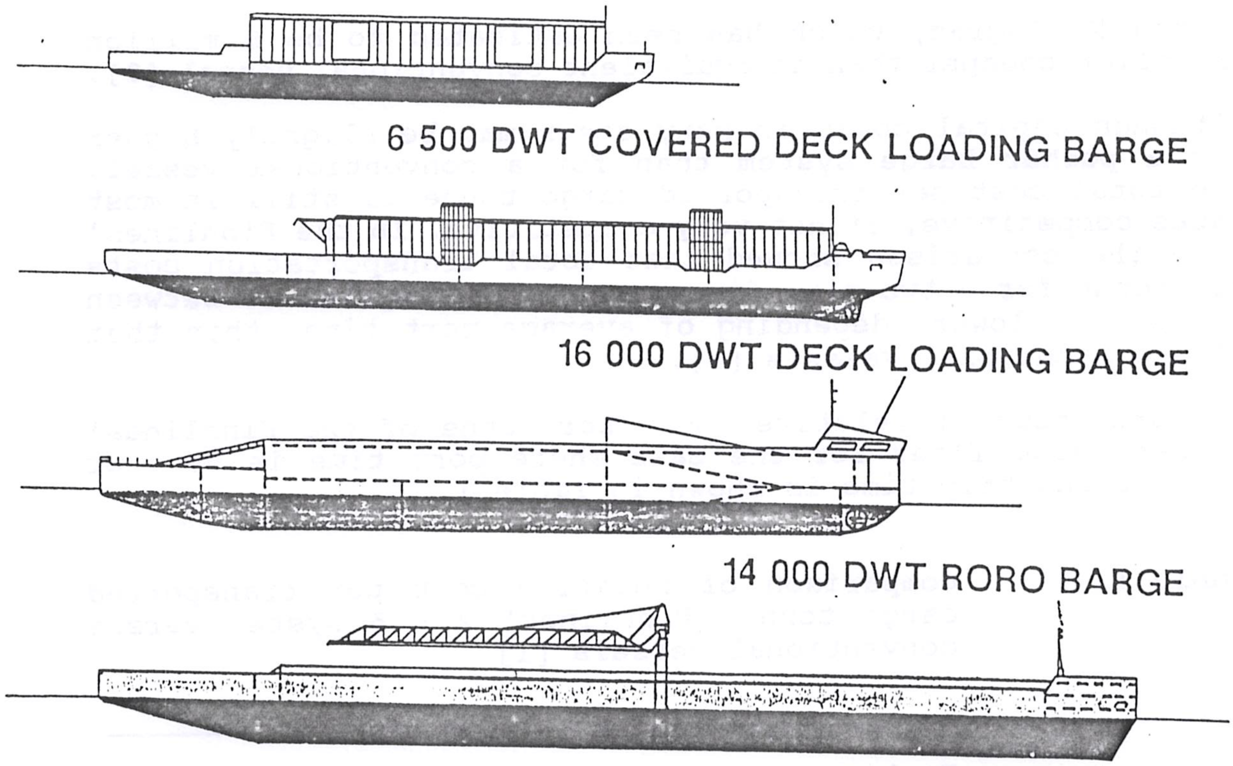


Fig. 4 Same examples of barges of different sizes and intended for different cargoes that can be used with same pusher.

5. Comparison with Conventional Vessels

Before any shipowner makes the decision of buying a pusher barge system, he will undertake one or more feasibility calculations. The result is depending on route length, cargo flow, crew cost, etc. The features of Wärtsilä Marine Locomotive type pusher barge system will in many cases outrange the conventional ship. The main reasons are:

- higher transport capacity due to higher turn around frequency
- lower crew costs
- about equal capital costs.

The two first items are easy to show and easy to understand. Capital costs however, is the item that is most variable of the three items. Depending on many reasons, such as country where intended to construct, eventual subsidizing, differences in outfitting level, etc. There are reported cases where the capital cost of a pusher barge system is higher than the equal conventional fleet, but also examples of the opposite, where the pusher barge system was less expensive than the conventional ship. An example of the former is the Finnlines pusher barge system [1], and an example of the latter is

Martha R. Ingram, which has been estimated to be 5 million US dollar cheaper than an equivalent conventional vessel [2].

Although capital costs in many cases may be slightly higher for a pusher barge system than for a conventional vessel. The total cost per transported cargo tonne is still in most cases competitive, if not very competitive. In the Finnlines' case the comparison showed that total transportation costs per tonne for a two plus five pusher barge system is between 21 to 32 % lower, depending of average port time, than that of a conventional vessels [1].

The breakdown of relative costs per tonne of the Finnlines' pusher barge fleet for the case where port time is 55 % of total round trip time is shown in Table 1.

Table 1. Comparison of relative cost per transported cargo tonne. Finnlines' 2 + 5 system versus conventional vessels [1]

Fuel costs	94 %	(conventional ship = 100 %)
Port costs	102 %	
Crew costs	30 %	
Other daily costs	57 %	
Capital costs	100 %	
Total costs	79 %	

The competitiveness of a pusher barge system is best in operation where the port time portion of total round trip time is relatively high, and the route length consequently short. The route lengths in the traffic Finnlines' pusher barges operate are between 95 to 700 nautical miles.

One important cost factor that must not be underestimated is needed investments into harbour facilities. Such investments may be of same order of magnitude as the investment into floating hardware. The fact that a longer harbour time can be allowed for the barges than for a conventional vessel will in many cases result in a remarkable saving, which affects the overall feasibility figures.

6. Future Possibilities

The future of the Wärtsilä Marine Locomotive (WML) type integrated tug barge (ITB) concept depends naturally on the future development of shipping generally, and especially coastal shipping as well as shipping in inland waterways. However, several features, in addition to general advantages of ITB systems which are well described in reference [3], of the WML are such that it is a promising alternative for several transportation needs, that are today serviced by conventional ships, or cannot be developed due to lack of cost effective transportation.

Such features and resulting possibilities can be summarized as follows:

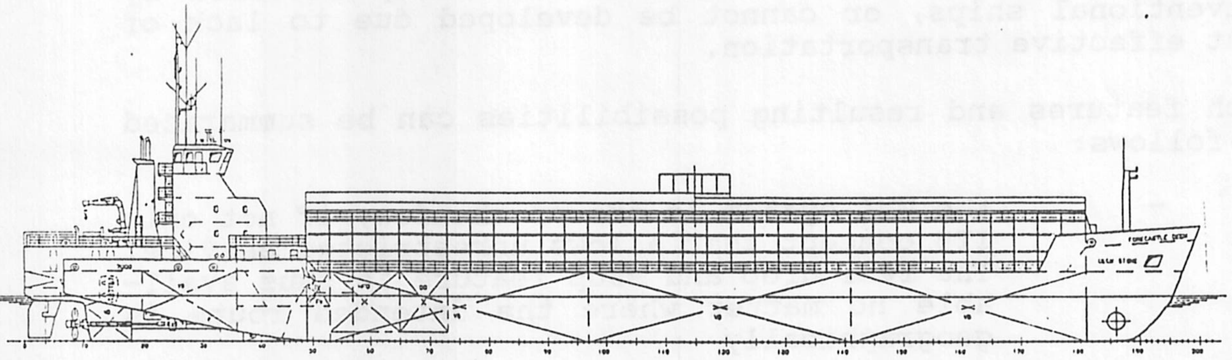
- the WML system is one of the few, if not only ITB concept that allows unrestricted service. The real drop and swop feature is thus available no matter where the intended route is geographically

- while combining the operating flexibility of an ITB system and the operating reliability of a conventional ship, the WML is available for transport needs where towed barges are not practical due to the high cargo volume

- the low transportation cost achievable with the WML system, together with the minor port requirements, makes the development of industry, mine etc. projects feasible, that would not be feasible using conventional modes of transportation

- by allowing the connection of a great range of barge sizes to same pusher, the WML system makes large scaled standardization possible, that can be compared with the standardization of containers. Nationwide coastal shipping can be covered by using e.g. two sizes of pushers and necessary barge types.

The WML system is a potential alternative in any part of the world, but most interesting are of course areas where potential growth is largest, e.g. South East Asia and South America. Figure 5 shows a pusher barge system with 6 000 tonne deadweight barges for bulk cargoes that could form the main body of a fleet serving domestic transportation in many countries.



6000 TDW COAL TRANSPORTATION SYSTEM

	Tug	Barge 6000 DWT	Tug + Barge 6000 DWT
Length, overall	30.1 m	115.3 m	120.1 m
Length, DWL	28.3 m	111.4 m	117.0 m
Beam, max	13.5 m	21.0 m	21.0 m
Depth, main deck	7.0 m	7.0 m	7.0 m
Draught, DWL	4.5 m	4.5 m	4.5 m

Fig. 5 A 6 000 tonne deadweight pusher barge system for bulk cargoes, with overall length of 120 meter, and draught of only 4.5 meter.

7. References

1 Pylkkänen, O., Segercrantz, H., "The Advantages of Integrated Pusher-Barge Transportation", Marintec China 85, Shanghai, 1985.

2 "Action in the ITB Market", Marine Engineering/Log, August 1980.

3 Trail, A., D., "Inland Waterways - The Maritime Link", International Cargo Handling Co-ordination Association, London, 1988.