LNG fuelled 'Port Feeder Barge' for very green container logistics within sea ports

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BIOGRAPHY

Ulrich Malchow started his career as a shipping trainee in the liner division of Hapag-Lloyd AG in Hamburg. Subsequently he studied naval architecture and mechanical engineering at the University of Hamburg and later at the Technical University of Aachen (RWTH Aachen).

Following his studies, he joined the Thyssen group of companies as a management trainee. At Blohm+Voss shipyard Ulrich rose to head both the sales and projects department for merchant vessels and mega yachts.

After leaving the shipyard he became managing director of the biggest barge operator within the port of Hamburg. Later Ulrich founded Port Feeder Barge GmbH to design, develop and eventually operate the new type of a "Port Feeder Barge" for advanced container logistics within the port of Hamburg.

In parallel Ulrich was appointed full professor for Maritime Economics in 2011at Bremen University of Applied Sciences at its Centre of Maritime Studies for 5 years.

Currently he serves also a senior consultant and partner for Wagener & Herbst Management Consultants specialising in intermodal and maritime logistics.

1. INTRODUCTION

Ports are a major source of greenhouse gases (GHG), i.e. mostly carbon dioxide (CO_2), and nitrogen oxides (NO_x). While CO_2 emissions are directly connected to the consumption of the respective fossil fuel and cannot be reduced other than by means of fuel saving (unless they are captured) NO_x emissions are different. They arise during the combustion process especially in diesel engines, e.g. in the engines of ships, cargo handling machinery, locomotives and trucks. NO_x emissions are rising when the combustion temperature and the cylinder pressure are being increased to achieve lower fuel consumption. This effect is meaningfully called 'diesel dilemma'.

In Hamburg the annual average NO_x limit set by the EU in 2010 of 40 $\mu g/m^3$ is being notoriously exceeded at several hot spots for some years now. The local government is obliged to take respective counter measures at speed now.

An analysis prepared by Hamburg's Environmental Authority for its Clean Air Scheme has come to the conclusion that approx. 50% of Hamburg's more than 20,000 tons of annual NO_x

emissions have their origin in the city's port business which also includes the emissions from trucking which by nature is to a substantial extend very much port related (Fig. 2).

Another analysis made by Hamburg Port Authority (HPA) has revealed that approx. 2 Mill TEU, which is almost ¼ of the entire container throughput, are being shifted just within the port either before loading or after discharging from seagoing vessels. This is done to 95% by truck and consequently contributes heavily to air pollution and road congestion within the port impeding its 'logistic flow' (Fig. 1). Hence by substantially shifting intra-port container haulage from road to waterway not only road congestion can be eased or at least bypassed but more importantly air pollution can be significantly reduced, i.e. especially Hamburg's NOx problem can be tackled.

However ordinary barges are in most cases not competitive for intra-port haulage compared to trucking as two additional moves by the big gantry cranes are necessary. One move by these cranes is already as expensive as the entire trucking within the port. Furthermore some container facilities have their own water access but no crane at all.

Fig. 1: Typical view on Hamburg's Koehlbrand Bridge linking the eastern and western part of the port

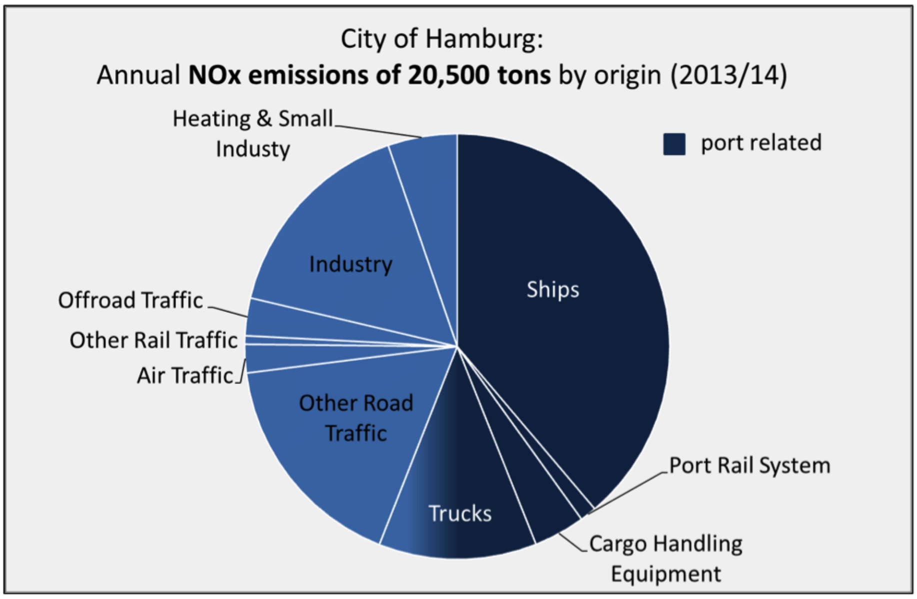


Fig. 2 *Source: Hamburg Clean Air Scheme (2017)*

Hence a self propelled container barge with its own full size container crane, providing independency from the availability and most importantly from the high cost rates of the quayside cranes would be very helpful to establish a competitive and green alternative to road haulage.

2. THE 'PORT FEEDER BARGE' CONCEPT

The internationally patented **Port Feeder Barge (PFB)** concept has been developed by the author to considerably improve the internal container logistics in major and minor container ports and reduce its ecological footprint. Key element of the self propelled pontoon type of vessel of 168 TEU capacity is its own full scale heavy duty container crane mounted on a high column (Fig. 3). The barge is of double-ended configuration, intended to make it extremely flexible in connection with the sideward mounted crane. Due to the wide beam of the vessel no operational restrictions (stability) for the crane shall occur. The vessel is equipped with 2 electrically driven rudder propellers at each end in order to achieve excellent manoeuvrability and the same speed in both directions. Hence the vessel can e.g. easily turn on the spot and navigate sideward as well. While half of the containers are secured by cell guides, the other half is not, enabling the vessel to carry also containers in excess of 40ft length as well as any over-dimensional boxes or even break bulk cargo. 14 reefer plugs allow for the carriage of electrically driven temperature controlled boxes.

Unusual for a shipboard crane it is equipped with an automatic spreader extendable from 20 to 45ft including a turning device. A telescopic over height frame to handle container flats with over height cargo is also carried on board. While it looks like a standard shipboard crane, all its mechanical components have been especially designed for continuous operation – unlike standard shipboard cranes, which are designed for operation only every few weeks when a seagoing vessel is in port. The crane has a capacity of 40 tons under the spreader with an outreach of 27 meters (maximum outreach: 29 m). With a skilled driver the crane performance is estimated to 20 moves/hour.

Fig. 3: Port Feeder Barge (computer rendering)

PORT FEEDER BARGE

Main Data

Type: .... self propelled, self sustained, double-ended container barge
Length o.a.: .... 63.90 m
Beam o.a.: .... 21.20 m
Height to main deck: .... 4.80 m
Max. draft (as harbour vessel): .... 3.10 m
Deadweight (as harbour vessel): .... 2,500 t
Tonnage: .... approx. 2,000 GT

Power generation: .... gas-electric
Propulsion: .... 2 x 2 electrical rudder propeller of 4 x 280 kW
Speed: .... 7 knots at 3.1 m draft

Class: .... GL ✠ 100 A5 K20 Barge
equipped for the carriage of containers, Solas II-2, Rule 19 ✠ MC Aut

Capacity: .... **168 TEU** (thereof 50% in cellguides), 14 reefer plugs
Crane: .... LIEBHERR CBW 49(39)/27(29) Litronic (49 t at 27 m outreach)
Spreader: .... automatic, telescopic, 6 flippers, turning device, overheight frame

Accommodation: .... 6 persons (in single cabins)

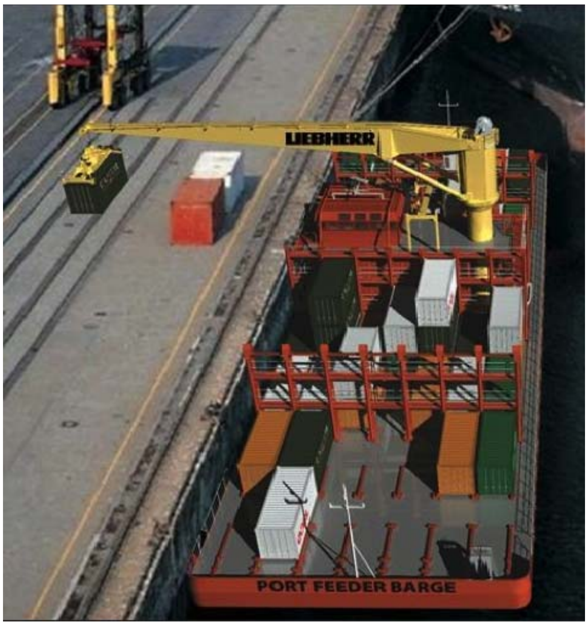


Fig. 4: Port Feeder Barge is working independently from quayside equipment at a deep sea terminal requiring only a small gap between two deep sea vessels (computer rendering)

When berthed, the **PFB** is able, without being shifted alongside the quay, to load or discharge 84 TEU in three layers between the rails of a typical quayside gantry crane (Fig. 5 b). This is more than sufficient, with a total loading capacity of 168 TEU. That is why the full outreach of the crane is not always needed. Berthing the vessel with the crane on the opposite side of the quay (Fig. 5 a) would speed up the crane operation as the turning time of the outrigger is less. The height of the crane column is sufficient to serve even high quays in open tidewater ports at low tide while stacking the containers in several layers. Due to its short length of 64 meters the **PFB** needs only a small gap between two deep sea vessels at a terminal for self sustained operation (Fig. 4).

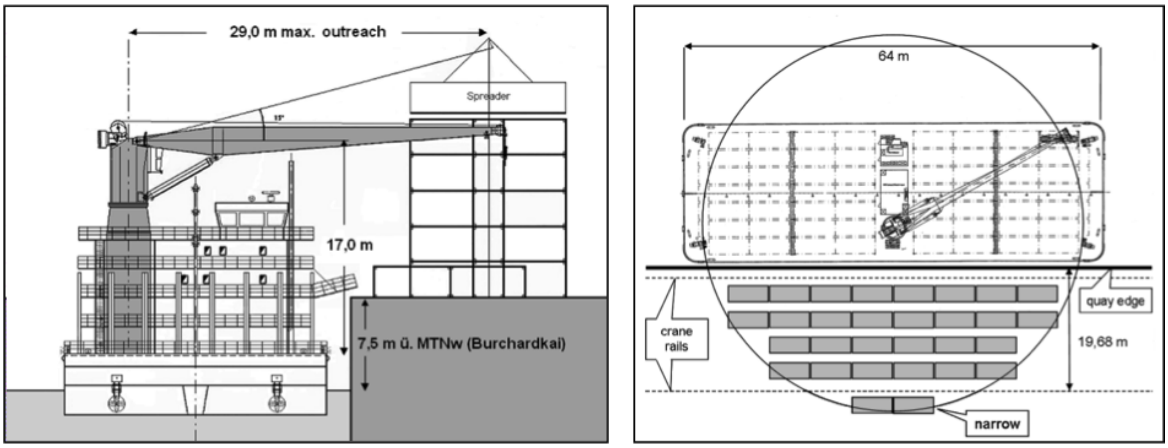


Fig. 5 a+b: Port Feeder Barge: outreach of crane and turning circle

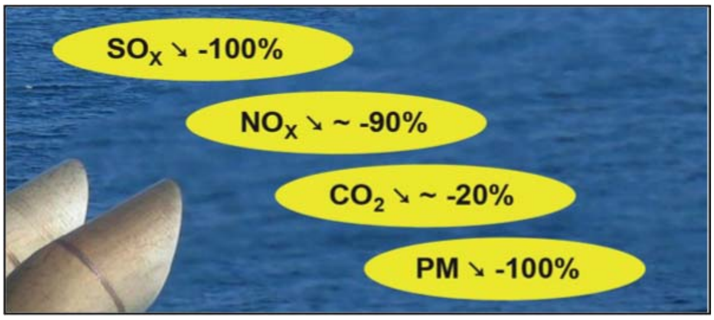
The operation of the **PFB** is not limited to inside sea ports. As the hull is classified according to the notification for seagoing vessels the operation in (sheltered) open waters off the coast is also possible which opens some further interesting opportunities for employment.

The vessel can be operated by a minimum crew of 3 whereas in total 6 persons can be accommodated in single cabins.

Bundling containers for waterborne transport is already much more energy efficient per TEU than the road haulage of single containers and causes less emissions per TEU. Also the standard shipboard crane of the **PFB** is less energy consuming than the huge quayside gantry cranes which are meanwhile tailor made to serve 20,000 TEU vessels and above. They are completely over dimensioned and consequently work only at low efficiency when serving the small vessels.

3. LNG AS FUEL

To further reduce the ecological footprint of intra-port container logistics the **PFB** is intended to be fuelled by LNG. A gas-electric engine plant with very low overall emissions supplies the power either for propulsion or crane operation which would result into an extremely 'green' harbour vessel.



Due to its special layout the **PFB** is very well suited to be fuelled by LNG. As the vessel is of pontoon type there is plenty of void space below the weather deck to accom¬modate the voluminous LNG tanks which would not result in any loss of cargo space as it would be the case with many other types of (harbour) vessels.

LNG is certainly still a fossil fuel and naturally causes GHG emissions (approx. 20% less) but compared to diesel it is a big progress with regard to the full range of emissions (Fig. 6) – even if a very small methane slip is considered.

Beside its core business the **PFB** would also be an ideal demonstrator and launching customer for LNG as ship fuel:

- As a harbour vessel it does not rely on a comprehensive network of bunker stations. Only one facility is sufficient.
- At first it could even be supplied out of a tank truck paving the ground from the demand side for a special LNG infrastructure to be introduced for this promising maritime fuel (solving the chicken-egg-dilemma).

4. INTRA-PORT HAULAGE

In Hamburg the PFB shall serve as a 'floating truck' in the course of a daily round voyage throughout the port carrying containers between its various container facilities (with water access). Hence container trucking within the port would be substantially reduced. As the PFB will be operated as a liner ('bus') service it can be booked even for single containers composing the majority in intra-port container shuttling.

According to the analysis of HPA approx. 400,000 TEU out of the 2 Mill TEU p.a. which are trucked within the port are well suited to be carried on the water as their place of origin as well as their place of destination have water access.

In multi terminal ports like Hamburg feeder vessels have to call at several terminals but are also big customers for intra-port haulage to avoid too much vessel shifting. As the **PFB** will offer a more competitive service than trucks can do, especially for lots of many or over dimensional boxes, the **PFB** would be used by the feeders more intensively than the trucks at present enabling the feeders to concentrate on a few terminals only. This would reduce the number of feeder vessel shiftings, reduce their time in port and related costs, improve safety (collisions) as well as increase terminal and berth efficiency.

5. INLAND NAVIGATION

Inland navigation is facing a dilemma as far as hinterland transport of containers is concerned. On the one hand there is a common understanding that its share in hinterland transport has to be substantially increased – for capacity and environmental reasons. On the other hand inland waterway vessels have to berth at the facilities which are tailor made for the biggest container vessels (20,000 TEU and above). Not surprisingly but most dis-advantageously inland navigation enjoys the last priority when it comes to berth allocation.

Inland barges have to call at even more facilities than feeder vessels. E.g. Rotterdam has approx. 30 terminals and depots which are frequently served by inland container barges. The average number of terminal calls per vessel is about 10 whereas in about 50 % of the calls only less than 6 containers are handled! This kind of inefficient and not coordinated 'terminal hopping' is very time consuming and each delay at a single terminal results in an incredible accumulated waiting time during the entire port stay. Not surprisingly only 1/3 of the port time is used for productive loading/unloading operation.

In Hamburg where inland navigation has still only a share of approx. 2% in hinterland transport of containers the inefficient operation has been identified as one of the major reasons for such a small share. Some Dutch and German studies dealing with the problems of transhipment procedures between inland navigation and deep sea shipping came to the conclusion that container handling for inland navigation and deep sea vessels should be separated from each other. In other words: Inland vessels should no longer berth at the deep sea facilities any more.

Fig. 7: The Port Feeder Barge is serving an inland barge midstream (computer rendering)

It is claimed that dedicated inland waterway berths have to be introduced at deep sea terminals. However most terminals do not have any shallow draught waterfront left where such berths could be meaningfully arranged. Transforming existing valuable deep sea quays to exclusive inland navigation berths with dedicated (smaller) gantry cranes does not pay off for the terminals as such a measure would reduce their core revenue earning capacity.
To spare the inland barges their inefficient 'terminal hopping' the erection of a central and dedicated inland navigation terminal within a port, where all inland barges call only once, has also been proposed. However this would burden the most environmentally friendly mode of hinterland transport with the additional costs of two further quayside crane moves and one additional transport within the port (either hopefully on the water but most probably by truck). The opposite of more waterborne container hinterland transport would be achieved. Hence increasing the share of inland navigation in hinterland transport of containers is really facing a dilemma in many major container ports.

The **PFB** could ease this dilemma by acting as a dedicated 'floating terminal' for inland navigation. During its daily round voyage throughout the port the **PFB** is collecting and distributing the containers also for inland navigation. Once a day, the **PFB** calls at a dedicated berth to meet with the inland barges where the containers are being exchanged ship-to-ship by its own gear, independently from any terminal equipment. Not even a quay is required but the transhipment operation can take place somewhere midstream at the dolphins as a virtual terminal call (Fig. 7).

6. OTHER APPLICATIONS

At sheltered places the PFB is also able to serve even seagoing container vessels (up to midsize) at anchorage. In minor or less developed or congested ports the **PFB** can help to facilitate container operation: quicker to realize, less costly and more flexible than any land based terminal facility.

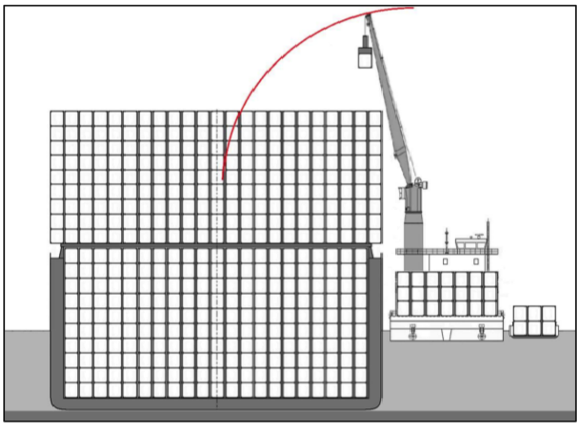


Fig. 8: Port Feeder Barge lightering a grounded 20,000 TEU vessel

At strategic locations the PFB can be used as a stand-by emergency response vessel for the quick lightering of grounded container vessels. It has to be conceded that virtually no port is really prepared for such incidents. The bigger the vessel the less salvage equipment is available. To lighter a 20,000 TEU vessel a floating crane with a hook height of approx. 60 m is needed. For serving such mega vessels the **PFB** had to be slightly enlarged by extending the crane beam and heightening the crane column (Fig. 8).

The acute lack of such equipment has been proven in 2016 when the 19,000 TEU vessel 'CSCL Indian Ocean' ran aground on Elbe River and was stranded for 5 days. Only due to very lucky circumstances the vessel finally did not need to be lightered. A 'green' port has to make also provisions for such scenario as a stranded vessel can easily suffer from structural damage which could cause a serious oil spill.

7. CONCLUSION

It is quite clear that the introduction of the **PFB** concept could reduce the ecological footprint of container logistics within major and minor ports of which many are suffering from heavy air pollution while at the same time significant improvements in intra-port container logistics are connected with the operation of **PFB**s (win-win-situation).

Despite all these obvious advantages, useful employment possibilities and economic viability the introduction, at least within the port of Hamburg, has been proven as not as easy as expected. Introducing such concept requires a lot of coordination with all the local stakeholders: political government, industry associations, port authority, terminal operators, unions, customs, liner agencies, container depots, stuffing & stripping companies, rail operators and truckers.

The **PFB** operation decisively on the consent of all terminals to allow for self sustained operation at their facilities. While even the local trucker association is supporting the concept it seems grotesque that in particular the biggest terminal operator which alone operates 3 terminals in Hamburg and which is even controlled by the government has refused its full support for 7 years now although the government has expressively committed itself already in 2015 to shift more containers to the waterway. Strange world!

In an advertisement campaign on occasion of the 50th anniversary of the 1st container vessel calling Hamburg it is clearly demonstrated what is obviously intended to be the ultimate future of intra-port container haulage (Fig. 9): It appears as if container haulage shall be directly shifted from road to airborne mode with no need for any advanced waterborne solution any more. Whatever the actual object of the advertisement is it is quite clear that someone has apparently lost ground while at the same time having not any clue about physics. Why aiming for the impossible when realistic solutions are so close?

Fig. 9: "With us boxes are learning how to fly" (translation), Source: several German newspapers, May 2018

Despite its innovative character (the concept is worldwide unique and protected by patents) it must be concluded that the introduction of the **PFB** is not a technical challenge. All components represent proven shipbuilding technology. Meanwhile even the gas-electric engine plant can be considered as just state-of-the-art. Hence constructing and operating the **PFB** can be done anywhere in the world. However the concept requires a new kind of cooperation among all the relevant stakeholders within the respective port. Hence new pathes of joint efforts have to be followed when introducing the **PFB** in order to get the full ecological and logistical return out of the concept.

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